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Indian Tea Association.

NOTES ON THE SPRAYING OF TEA

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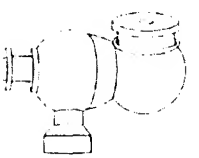
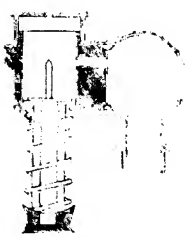
Bordeaux type of nozzle.



Swivel type of nozzle.



Vermorel type of nozzle.

NOTES ON THE SPRAYING OF TEA.

INTRODUCTORY.

Of late years there have been many improvements in the general routine of tea culture in North-East India. The incidence of various pests and blights of a serious nature has demonstrated from time to time the need for some further improvements in this routine which will have the effect of eradicating them, or at least reducing their ravages.

The best safeguard against disease is good health, and careful attention to soil treatment, pruning, and plucking has already reduced a number of diseases which were at one time serious to an insignificant position. There are, however, many pests and blights which have the power of attacking healthy vigorous plants, and active measures are required for their removal. Up to the present time the most successful method of combating the attacks of pests and blights, apart from improving the hygiene by every available means, is by spraying liquids of various composition over the surface of the affected organs.

The layer of liquid may act in three ways; firstly, as a protective coating preventing the animal or vegetable parasite from attacking the plant; secondly, by killing the parasite either by direct contact, or, in the case of certain insecticides, by stomach poisoning; thirdly, the spray fluid by being absorbed by the tissues of the plant may cause changes which render the plant immune or partially so from the attacks of the parasite. Some spray fluids moreover, *e.g.* Bordeaux mixture and lime sulphur wash, stimulate the functions of the tissues, and so directly improve the health of the plant and its power of resisting disease. Organisms such as lichens, mosses, and ferns, which are not actually parasitic but which, by interfering with the normal growth, cause ill-health to plants, may also be removed by suitable spray solutions.

A tea bush is a particularly convenient form and size of plant for this method of treatment. The low habit which is produced artificially by pruning, in order primarily to enable the bushes to be plucked easily and rapidly, is a great advantage when spraying is undertaken. The distance apart of bushes is so arranged that labourers can easily pass from bush to bush, and this too is another advantage in the case of tea, and the fact that it is a perennial plant enables one to deal with it by spraying at all times of the year.*

All garden operations are to some extent interdependent, and spraying is one operation only in the successful treatment of pests and blights. Spraying, to be completely successful, must be supplemented by special and liberal adaptations of such other operations of general garden routine as conduce to improving the health of the bushes and their power of resisting disease. This involves the expenditure of a certain amount of labour and money, and the question arises as to whether the advantages obtained compensate for the outlay. Until recent years no attempt had been made to carry out spraying on a large scale in the tea districts, and at this stage it is only possible to argue in its favour by analogy, by quoting the results obtained in the cultivation of other plants. Twenty years ago the vine-yards on the banks of the Rhine were, in regard to spraying, in the same position as tea gardens are to-day. It was then acknowledged by vine-growers that spraying was desirable but doubt was expressed as to whether it would be possible to carry it out profitably. The vine-growers now find that it pays to spray their vine-yards not only once or twice but even six or seven times annually. It may be argued that since vines are grown for fruit and not for leaf the conditions are not similar to those which obtained in the case of tea, but spraying has also been found profitable in the cultivation of plants grown for their foliage such as cabbages, lettuces, and tobacco. For the successful intensive cultivation of such plants it is now recognised as a necessity.

*The necessity for arranging the time of spraying so as to leave the bushes unplucked until an entirely new flush has grown, will of course be understood and acted on in all cases of spraying (see p. 8).

Most managers of tea estates now realise that the pests and blights which attack tea not only cause immense annual loss in crop but tend to produce general debility of the bushes, and in consequence serious attempts have been made during the past year to spray large areas of tea.

Spraying is a new departure in tea culture and many mistakes have been made in the initial efforts. In some cases the efficacy of the spray solutions has been impaired by using the wrong chemicals, or solutions made up in wrong proportions. In a few instances also solutions have been rendered valueless by being prepared and kept in vessels of unsuitable materials. These are two instances only of mistakes which can only be avoided by understanding the main principles which underlie the use of spraying machinery and the preparations of spray fluids, and it is hoped that this pamphlet will help planters to acquire a more definite knowledge of the subject, and that this knowledge, when acquired, will induce more planters to take the matter up.

INSECT CONTROL.

The aim of every agriculturalist is to obtain the maximum amount and best quality of produce. Insects, by interfering with the natural growth of the various parts of plants, cause losses in crop and often decrease in quality, and those which are harmful must therefore be eliminated if the best results are to be obtained. This fact was recognised by cultivators in very early times, and they commenced to put various obnoxious substances on to their plants, with a view to keeping insects away. Some of these substances were found to be effective, and the practice was continued and extended until, to-day, it is followed by every up-to-date cultivator, and hundreds of men are engaged in the investigation, and thousands in the manufacture, of materials and machines for the spraying of plants, as a means of combating insect pests. At first the choice of a substance with which to spray was made in a more or less haphazard fashion. It was thought that the substances most obnoxious to man must be most objectionable to insects, and extraordinary mixtures of substances were used. Later, however, people began to study the subject seriously and methodically. They began to notice that all insects did not attack the bush in the same manner, and that different classes of substances had to be used in dealing with different pests, and that one substance could be used on one plant, but not on another, or on the same plant at one time of year, but not at another; that a substance would kill an insect at one stage of its life history, while having no effect on the pest at a later stage, and so on. And so, by degrees, it came to be recognised that the control of insect pests is not simply a question of putting a poison on the plant, but is a scientific problem of some complexity, requiring for its elucidation an extensive knowledge of the life history and habits of insect pests, of the properties of chemical substances, and of the economy of plant life. The study of this problem was therefore handed over to specialists, and now takes a place of

PLATE II.

A very satisfactory type of nozzle

1. Brass bowl 2. Gauze strainer 3. Washer 4. Disc which gives the rotary motion to the fluid 5. Washer 6. Aperture.

Below is a diagram showing the arrangement of the above parts.

This type of nozzle is sold under various names.

almost equal importance with the study of soils, manures, and other factors of importance in agriculture.

A consideration of the problem shows that the depredations of insects may be conceivably lessened in one or both of two ways; first, by attacking the insect; second, by rendering the bush unpalatable to it or immune from its attacks. The last method is very seldom practised, as very little is known of the effects of different substances on plants. Control is generally attempted by directly attacking the insects.

Insect pests may be divided into two classes, those which suck the plant juices and those which eat the plant tissues, and the recognition of this fact was one of the most important steps in the development of rational methods of spraying. An insect which feeds by biting off and swallowing portions of the plant may be killed by putting on to the plant a poison which it will swallow with its food, but when an insect pest feeds by sucking the juices from the interior of the plant tissues such an application of poison is obviously useless, as the poison will not be taken into the stomach. Insects which feed in this way must be treated by means of a substance which will kill the insect when it comes into contact with it. In consequence, insecticides are divided into two great classes, *poison insecticides*, applied to the plant and swallowed by the insect, and *contact insecticides*, applied to the insect and killing it in some way on coming into contact with it externally. We give here, for the sake of clearness, the distinctions between poison and contact insecticides in tabular form:—

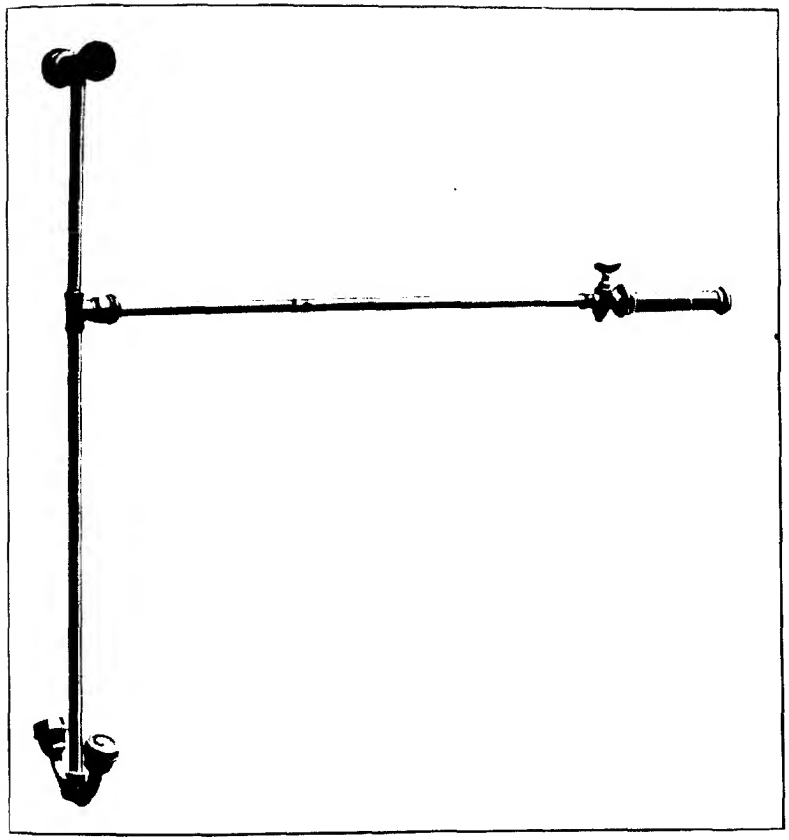
Poison insecticides.	Contact insecticides.
Examples.	
Lead arsenate.	Soap solutions.
Lead chromate.	Oil emulsions.
Paris green.	Alkali washes.
Copper salts.	Rosin washes.
Used against	
biting insects.	Sucking insects.

	Applied to	
the plant	...	the insect—only secondarily to the plant, as the insect happens to be on the plant.
May be applied before the insects appear, so as to poison the first-comers and control the attack from the start.		Must be applied when the insect is on the plant. Previous application is of little or no value.

In addition to these two classes of insecticides, a third class, known as *fumigants*, may be defined. These are substances whose action depends on the suffocating power of a vapour, and are chiefly used in confined spaces, such as greenhouses, granaries, etc. Carbon bisulphide, and naphthalene, for instance, are extensively used for the purpose of protecting grain from the attacks of weevils. Several fumigants have been tried against tea-pests, with small success, but mention will be made later of a substance supplied for use with the "Universal" White Ant Exterminator, which has been found to be of value for destroying white ants in godowns, etc.

From the foregoing remarks on the differences between *poison* and *contact* insecticides it will be readily seen that before deciding on a spray mixture to be used against an insect pest, the method by which the insect feeds must be taken into account, but this is not the only factor to be considered. Not only does the method according to which the insect feeds affect the question, but its nature, habits, and life-history in general must be taken into consideration also. Some sucking insects are protected by a hard coat, which is exceedingly resistant to the action of contact insecticides, and it is consequently useless to apply them. This is the case with the tea-seed bug (*Poecilocoris latus*) for which a satisfactory contact insecticide cannot be recommended. Certain scale insects also have hard outer coverings which afford them complete protection. In such cases spray fluids are applied which

PLATE III.



The I. T. A. attachment complete with strainer rod.

kill the insects, not directly, but either (*a*) by gumming the scale to the bark, so that the insect is imprisoned, *e.g.*, resin washes, or (*b*) by acting on the outer covering so that it shrivels up, and the insect falls off, *e.g.*, certain alkali washes.

When a *contact* insecticide is sprayed on to a plant infested by a species of active sucking insect, although it may be known to kill the insects when applied to them, it will cover a smaller percentage of insects than an equally effective substance sprayed on to sluggish or sedentary pests, and effective spraying is thus rendered more difficult in the case of active insects than in the case of sluggish ones.

We have elsewhere given an account of the insect life cycle (Indian Tea Association, Scientific Department Quarterly Journal, pt. II, 1913, p. 33), and have there shown that in the case of some insects, *e.g.*, the tea mosquito (*Helopeltis theivora*) there is no great difference between the appearance and habits of the insect at different stages of its existence, while in other cases, *e.g.*, the looper (*Biston suppressaria*) there are three distinct stages, in each of which the insect has a characteristic appearance and behaves in a characteristic manner. In regard to the former group of insects a method of treatment which is successful at one stage will, as a rule, be successful at any other stage,* but in the latter group this is not the case, and each agriculturist must observe carefully the occurrence of the various stages on the particular estate, and apply the remedy accordingly. In the case of a caterpillar pest, for instance, such observations must be made. A pest of this kind may usually be dealt with by means of a poison insecticide, but when it becomes full-grown it changes into a chrysalis, or pupa, in which stage it does not eat, and is therefore not affected by poisons, and in this stage, also, it is protected by a thick case impervious to contact insecticides. The next and last stage is that of the moth or butterfly. In this stage the insect either does not feed, or, if it does, it feeds by sucking the juices of flowers, perhaps of some plant entirely different from that on

* We except the egg stage. Insect eggs are exceedingly difficult, in most cases impossible, to deal with by means of sprays.

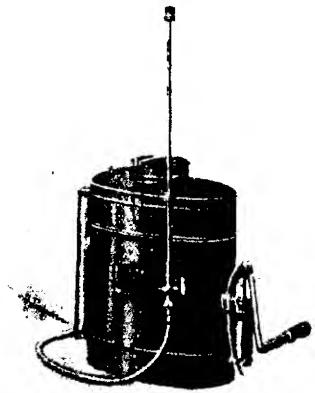
which the caterpillar is found. It is obvious, then, that in such cases a poison insecticide is of no value except during the caterpillar stage, and that in subsequent stages other methods must be adopted, such as collecting the chrysalides, or attracting the moths by sugaring or by light.

Spraying methods have often to be modified on account of the nature of the plant attacked, and the purposes for which the plant is grown. A substance which may be sprayed on to one bush with impunity might seriously damage the foliage of another, and remedies which are effective and safe to use on a tree grown for fruit, are often too unsafe to be used on a plant grown for its leaf. This is especially the case with regard to the spraying of tea-bushes, and one would emphasize, at this point, the fact that *all spray substances used against tea pests should be applied to the bushes as soon as possible after they have been plucked, consistent with applying the insecticide at the proper stage in the life history of the insect.*

PLATE IV.

Continuous-Pumping Sprayer.

Pump external.



The "Gem" Knapsack Sprayer.

SUGGESTIONS FOR THE TREATMENT OF CERTAIN INSECT PESTS OF TEA.

(*Serica assamensis.*)

Watt & Mann, "The Pests and Blights of the Tea Plant," 2nd ed., p. 169.

Nature of damage.—Eats away the tissues of the old leaves, leaving the veins, and giving the appearance of skeleton leaves.

Treatment.—Spray the bushes and the jungle beneath them with lead chromate, preferably towards evening. The beetles and their larvae may be captured in large numbers in the daytime by turning up the surface soil below the bushes. A little nitrolim forked into the soil round the bushes will help matters.

THE ORANGE BEETLE OR PEAL'S BEETLE.

(*Diapromorpha melanopus.*)

Watt & Mann, "The Pests and Blights of the Tea Plant," 2nd ed., p. 170.

Nature of damage.—The beetle eats partly through the succulent green stem of the shoot, and the young leaves droop, fall over, wither, and eventually drop off.

Treatment.—Spraying the bushes is wasteful, and is not of great value, as poison insecticides are not likely to stick in sufficient quantity to the part affected. The pest comes from the jungle, where it breeds, and the destruction of the latter is the best means of eradicating the beetle. The pest, too, may be caught by children and this doubtless does a great deal of good, but so long as there is jungle in which the insects can breed they will come into the tea.

The Bunch Caterpillar.

(*Andraca bipunctata.*)

Watt & Mann, "The Pests and Blights of the Tea Plant," 2nd ed., p. 180.

Nature of damage.—The caterpillars eat away the whole of the leaf, leaving only the stump of the leafstalk on the stem. They often completely strip the bush.

Treatment.—Their habit of spending the day in a cluster on the stem of the bush renders their capture in large numbers so easy that other measures are unnecessary.

The Lobster Caterpillar.

(*Stauropus alternus.*)

Watt & Mann, "The Pests and Blights of the Tea Plant," 2nd ed., p. 183.

Nature of damage.—The leaf is eaten away from the tip to the base. The caterpillar is easily recognised by its habit of erecting the hind part of its body.

Treatment.—Spray with lead chromate.

The Red Slug.

(*Heterusia magnifica.*)

Watt & Mann, "The Pests and Blights of the Tea Plant," 2nd ed., p. 185.

Mann & Antram, "The 'Red Slug' Caterpillar," Pamphlet, No. 16, 1906, Indian Tea Association.

Nature of damage.—The caterpillar eats away the whole leaf, often completely defoliating the tea bushes. It is easily recognised by its thick body, its red colour, and the presence on its back of tubercles provided with hairs which secrete a viscous fluid.

Treatment.—The eradication of this pest is an arduous and expensive task. Spraying, if adopted, must be carried out with the object of driving the insects into a small area of the garden,

where they can be easily caught in large numbers. These caterpillars, as a rule, do not eat the sprayed foliage, but go to an unsprayed bush, and as they can travel a considerable distance spraying should be commenced some way from the affected area, and carried towards the centre of this area. Lead chromate may be used for this purpose, and Mann and Antram state that sulphur is effective. The migration of the caterpillars may be restricted by a line of fresh wood-ashes a few inches wide, which the creeping caterpillars will not cross, or by means of crude petroleum. The caterpillars shelter in the ground and in the dead material at the foot of the bushes during the heat of the day, and feed at morning and evening, and this habit should be borne in mind if catching is resorted to. Ringing the bushes, where possible, with a sticky substance such as petroleum grease or "tanglefoot," between 11 a.m. and 3 p.m., would prevent the caterpillars from getting into such bushes as are ringed, but this would have to be done as nearly as possible simultaneously over a large area, owing to the insect's powers of migration, and might be a difficult operation where the frames of the bushes are low.

The Faggot and Bag Worms.

(*Clania crameri.*)
(*Clania holmesi.*)
(*Clania variegata.*)
(*Amatissa consorta.*)

Watt & Mann, "The Pests and Blights of the Tea Plant," 2nd ed., pp. 188, 189, 190, 192.

Nature of damage.—These insects cause serious damage by eating the leaves of the bush, but in many cases they are found to feed on the bark, and they then become very troublesome pests.

Treatment.—Spraying is not of great value against these pests. Collecting the cases found at the very beginning of the

season, is much the best method of dealing with them. It is very important to begin collecting early, as soon as one or two have been seen on the bushes.

The Limpet Caterpillar.

(*Acanthopsyche reidi.*)

Watt & Mann, "The Pests and Blights of the Tea Plant," 2nd ed., p. 193.

Nature of damage.—This insect is easily recognised. It has a conical grey case, perfectly smooth, which looks like a grey thorn on the bush. It feeds on the upper side of the leaf, and eats away the upper epidermis in a small circular spot about $\frac{1}{8}$th inch in diameter. In serious cases it may eat similar circular patches of the bark of the twigs and stems.

Treatment.—Spray the bushes with lead chromate.

The Nettle Grub.

(*Thosea cervina.*)

Watt & Mann, "The Pests and Blights of the Tea Plant," 2nd ed., p. 203.

Nature of damage.—This caterpillar attacks the leaves, eating a piece off the end or from the side. Its capability of stinging makes it a source of great annoyance to the pluckers.

Treatment.—Spray the bushes with lead chromate.

The Gelatine Grub.

(*Belippa lohor.*)

(*Belippa caleana.*)

Watt & Mann, "The Pests and Blights of the Tea Plant," 2nd ed., p. 209.

Nature of damage.—This pest eats pieces out of the old leaves. The caterpillar has the appearance of a brownish or green translucent jujube, ovoid in form.

Treatment.—Spray with lead chromate. This pest is seldom known to become virulent, and under ordinary conditions is kept in check by a parasitic fly.

The Bark-eating Borers.

(*Arbela spp.*)

Watt & Mann, "The Pests and Blights of the Tea Plant."
2nd ed., p. 223.

Antram, "The Bark-eating Borers of Tea," Pamphlet.
No. 21, 1907, Indian Tea Association.

Nature of damage.—The caterpillar bores into a branch at a place where the bark is stripped, and lives there. It emerges from the hole to feed, and as it feeds builds up a tube of a sort of silk to which are attached small pieces of bark, which adheres to the branch. The branch may be almost completely stripped. A favourite place for the hole in which the caterpillar lives is at a fork in the bush, or where a snag left in pruning has died back.

Treatment.—This pest prefers old, hidebound bushes. The affected bushes should be treated in the cold weather with alkali wash, to soften the bark, and render it less liable to attack. It is not worth while spraying to kill the caterpillar. Directly it is disturbed it retreats to the hole in the branch, and if it be killed, the hole it made is still left, and the bush will be liable to attack by all kinds of borers, white ants, etc. All affected branches should be cut off and burnt. Too great stress cannot be laid upon the fact that good and careful pruning will do much to lessen the liability of the bushes to attack by these pests.

The Looper.

(*Biston suppressaria.*)

Watt & Mann, "The Pests and Blights of the Tea Plant,"
2nd ed., p. 225.

Antram, Indian Tea Association, Scientific Department,
Quarterly Journal, pt. I, 1911, p. 2.

Nature of damage.—The caterpillar eats the whole of the leaf, and in a bad attack the bushes may be completely defoliated.

Treatment.—Spray with lead chromate. This pest has been almost entirely eradicated on gardens where it was in former years a serious pest, by hand-forking the bushes during the cold weather, and collecting the chrysalides found at the foot of the bushes, and by sending children round the garden, during the periods when the moths are in evidence, to kill them with sticks while they are at rest on the Sau trees.

The Sandwich Caterpillar.

(*Agriophora rhombota.*)

Watt & Mann, "The Pests and Blights of the Tea Plant," 2nd ed., p. 235.

Antram, Indian Tea Association, Scientific Department, Quarterly Journal, pt. I, 1912, p. 2.

Nature of damage.—This caterpillar draws together the leaves of the bush, and makes a sort of house by fastening these together by silken threads. It then feeds on the leaves, and in severe cases attacks the bark.

Treatment.—Spraying with poisons has proved to be of little use against this pest. On gardens which are badly attacked it is often the practice not to clean out the bushes when pruning, in order to confine the attacks of the insect to the foliage, when the bushes are not so badly damaged as when the insect attacks the bark. A better method of dealing with this evil can now be suggested, namely, to clean out thoroughly when pruning, bury the prunings as quickly as possible, and then treat the bushes with alkali solution.

The Tea Mosquito.

(*Helopeltis theivora.*)

Watt & Mann, "The Pests and Blights of the Tea Plant," 2nd ed., p. 247.

Mann, "The Mosquito Blight of Tea," pts. I, II and III, Indian Tea Association, pamphlets Nos. 3. 7, 10.

Mann, *Helopeltis theicora*, Memoirs of the Department of Agriculture, Pusa, vol. I, No. 4.

Antram, "The Mosquito Blight of Tea," Indian Tea Association, pamphlets 1908, 24 ; 1909, 26 ; 1910, 30

Andrews, Indian Tea Association, Scientific Department, Quarterly Journal, part I, 1914, p. 31

Andrews, Factors affecting the Control of the Tea "Mosquito Bug," Indian Tea Association, pamphlet No. 48, 1923.

Nature of damage.—This insect punctures the leaves, producing characteristic brown patches, and in bad cases blackening the entire shoot. It prefers the young plucking shoots, and in severe attacks these are all killed out, and the buds are attacked, with the result that the bushes cease to flush.

Treatment.—Spray fluids are useless in the case of a bad attack, although Antram's soap solution has been known to aid in checking a mild one. In cases where this pest has been held in check it has been the result of a combination of spraying, hand-catching, and cultural methods, and it is difficult at present to assign a proper value to each.

The Tea Green Fly.

(*Empoasca flavescens.*)

Watt & Mann, "The Pests and Blights of the Tea Plant," 2nd ed., p. 286.

Antram, Indian Tea Association, Scientific Department, Quarterly Journal, pt. III, 1911, p. 1.

Nature of damage.—This pest, by puncturing the young leaves, produces a stunting of the shoots. In such shoots the leaves are very small, the interspaces between the leaves are shortened, and the whole shoot grows very slowly. In severe attacks the parent shoot may remain so small that it is not plucked, and subsequent shoots from this are similarly punctured and stunted, with the result that a broom-like appearance is produced.

Treatment. This insect, owing to its habits and great activity, is very difficult to treat by spraying methods. Strong crude oil emulsion, or potassium sulphide, will kill the pest, but the spraying must be done exceedingly thoroughly, care being taken that every part of the bush is thoroughly wetted, and even then a large number of the insects manage to avoid the spray.

The Tea Aphis.

(*Toxoptera theaecola.*)

Watt & Mann, "The Pests and Blights of the Tea Plant." 2nd ed., p. 293 ff.

Nature of damage.—The pest is to be found on the young shoots of the bushes, and on the young plants in the nursery. Its effect on the plant is characteristic. The young leaves curl over, and become somewhat crinkled in appearance, and on examination the under surface and the stem are found to be infested by small, black, globular insects. In addition to these a number of ants will usually be found, attending the insects for the purpose of procuring a juice which they exude.

Treatment. Crude oil emulsion, rosin solution, or a weak solution of phenyle (1 in 200) are all effective remedies for this pest.

Scale Insects.

(Various species of *Coccidae.*)

Watt & Mann. "The Pests and Blights of the Tea Plant." 2nd ed., p. 298 ff.

Nature of damage.—These pests suck the sap of the plant, and are easily recognised, as they have the appearance of small scales on the leaves or bark.

Treatment.—The best treatment for these pests is the application of soda in the cold weather, followed by a rosin solution about May or June. Better than the soda is the emulsion-soda. The solutions may be sprayed on to the bushes, or, better, brushed on with a stiff brush.

Thrips.

(Various species of *Thrips*.)

Watt & Mann, "The Pests and Blights of the Tea Plant," 2nd ed., p. 320.

Antram, "The Thrips Insect," Indian Tea Association, pamphlets 1909, No. 27.

Nature of damage.—This pest causes stunting of the young shoots very similar to that produced by green fly.

Treatment.—Spraying against Thrips is of doubtful value, owing to the fact that it creeps inside the buds, and is untouched by the spray fluid. Lefroy recommends a rosin solution. Recent researches have shown that Thrips may be caught by means of traps. These traps consist of small bowls each containing about ½ pint of water in which a thimbleful of benzaldehyde has been stirred up. The insects are attracted by the benzaldehyde and drowned in the water. The traps must be scattered about the affected area. Each trap maintains its efficiency for five or six days.

White ants.

(Various species of *Termites*.)

Watt & Mann, "The Pests and Blights of the Tea Plant," 2nd ed., p. 322.

Nature of damage.—Several species of Termites are found in the tea districts. They live in nests in the ground, and attack the bushes, in the first instance at some place where dead wood occurs. From there they work their way into the bush, killing out and eating away the heart-wood as they go, until the woody parts are reduced to a mere shell, and the bush sickens and dies in consequence.

Treatment.—No spraying methods are of any value. Good cultivation and careful pruning do more than anything else to prevent damage by this pest. In the case of mound-forming species however, where each separate colony can be readily defined, the "Universal" White

Ant Exterminator has been found very useful. This machine consists of a brazier, in which is placed burning charcoal and a quantity of a powder, supplied by the makers of the machine, which gives off heavy fumes when heated by the charcoal. This is connected, on the one hand, with a pump, and on the other hand with a metal nozzle. The latter is inserted into one of the main galleries of the nest, and by working the pump fumes are forced into it. After a time the fumes will be seen to be coming out at other places. All these holes are stopped up by means of wet clay, and the pumping continued until the pressure becomes so great that the coolies can pump no longer. The machine is then removed, the gallery into which the fumes were pumped is closed by wet clay, and the nest left for three or four days, after which time it will be found to be destroyed. The powder supplied with the machine consists mainly of sulphur and arsenious oxide.

The Red Spider.

(*Tetranychus bioculatus.*)

Watt & Mann, "The Pests and Blights of the Tea Plant," 2nd ed., p. 348.

Nature of damage.—This pest sucks the juices of the plant, commencing as a rule on the older leaves, giving them a reddish-brown dried-up appearance. In severe attacks the leaves fall off, and the damage extends to the young shoots. The presence of the pest can be easily detected even at a distance, by the reddish appearance of the bushes, and close observation will show numbers of small red mites running about the leaves.

Treatment.—Sulphur has, up to the present, been the recognised remedy for this pest, but of late years complaints have been made that it has ceased to be effective. This has been put down to the sulphur being impure, but that this is not the case has been shown by the results of analyses

undertaken by this department. If a leaf affected by Red Spider be covered with sulphur, it will be often seen that, although most of the individuals may be killed, some will crawl away, apparently unaffected, and it seems not unlikely that in time the majority of these mites on a garden which has been regularly sulphured may consist of descendants of these immune individuals, in which case the action of the sulphur will be less marked. Similar decrease in the effectiveness of insecticides against these pests has been noticed in America. The remedy seems to be in the choice of a suitable insecticide of a different type, and if necessary, in alternations of sulphuring and spraying. Such suitable insecticides are:—potassium sulphide, crude oil or kerosene emulsions, and lime-sulphur solution.* Potassium sulphide is perhaps the best. In spraying for Red Spider care must be taken that the whole of the bush is thoroughly saturated, and it should also be remembered that none of these spray fluids will kill the eggs, and that unless a second spraying is carried out four days later lasting results cannot be hoped for.

The Scarlet Mite.

(Brevipalpus obovatus.)

Watt & Mann, "The Pests and Blights of the Tea Plant," 2nd ed., p. 359.

Nature of damage.—This pest is to be found on the under-surface of the leaves, and its web is confined to the base of the leaf. The leaf first becomes pale, and finally withers, turns dark brown, and falls off, the final result of its depredations being very similar to that produced by Red Spider.

Treatment.—Potassium sulphide or crude oil emulsion, sprayed on to the bushes *from below.*

* Soap solution is said to have been found of value in Darjeeling.

The Pink Mite.

(*Phytoptus theae.*)

Watt & Mann, "The Pests and Blights of the Tea Plant," 2nd ed., p. 368.

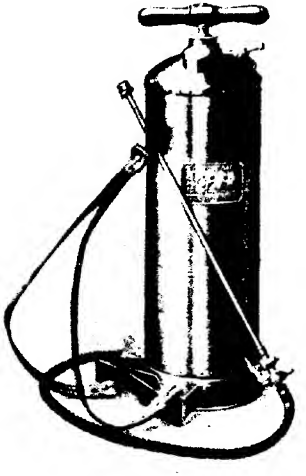
Nature of damage.—The pest is very difficult to detect, since the result of an attack is merely to give the bush a sickly appearance. The leaves turn somewhat brown, but do not fall off. When the mite is present, however, it can be recognised by examining the under-surface of the leaf with a pocket lens, where the minute pink mites running about the leaf will be seen.

Treatment.—Spray the bushes *from below* with potassium sulphide or crude oil emulsion.

PLATE V.

Pressure Sprayer.

Self-contained type.



The "Kent" Pressure Knapsack Sprayer.

FUNGUS CONTROL.

Examination of any piece of jungle will show that almost every tree and plant in it is suffering from diseases to a greater or less extent. If plants, growing in the surroundings to which they have been adapting themselves for ages, are yet subject to disease, it is not surprising that the tea plant, removed from its usual environment and growing under unnatural conditions should be affected. The conditions tending to control and limit the attacks of pests and blights which cause disease are in many cases absent in the environment of cultivated plants, and unless artificial control be introduced the diseases may, and often do, assume very formidable proportions.

Many of the diseases of tea are caused by fungi. The attack of a fungus may be likened to that of an invading army, and just as in military operations it is necessary to know something of the character and dispositions of the enemy before making a plan of attack so it is important that the nature and behaviour of the fungus causing the disease should be known so that the best methods for its control may be formulated. This pamphlet has not been written with the object of discussing in detail the life history of the fungi and other plant parasites which cause disease of tea, but confines itself as far as possible to a discussion of artificial means of combating pests and blights. The individual fungi will only be discussed sufficiently to render intelligible the descriptions of the machinery used in their control.

A fungus is a plant. It differs from green plants in that it is unable to feed on substances of simple chemical composition but requires solutions of food material which have been elaborated by other organisms. Green-leaved plants have the faculty of absorbing energy direct from the sun and using it to build up complex food substances out of simpler chemical substances. One of the main functions of fungi on the other hand is to break up

these latter into simpler substances which may eventually be used again by the green plant.

Fungi may be classified according to their method of nutrition as follows :—

1. saprophytes ... feeding on dead matter only :
2. facultative parasites ... feeding on living or dead organic matter according to circumstances :
3. obligate parasites ... feeding on living matter only.

Some parasitic fungi cause disease of animals but most of them attack plants. They may attack plants in two ways :—

1. living outside the host plant, and sending specialized absorbing organs into its tissues, *e.g.*, Mildews, Thread blight :
2. living inside, and feeding on the host plant, except at certain stages of their life history, *e.g.*, Blister blight, Copper blight.

Fungi are generally propagated by means of spores. The methods by which fungus spores are distributed are very interesting. All manner of devices are employed to ensure their dissemination. Wind, insects, animals, and human beings are among the agencies employed. The spores of a given parasitic fungus usually only infect one or at most a few closely allied species of plants. There are cases, however, where a fungus spends some stages of its life history on one kind of plant and other stages on another totally different one.

When a fungus spore, alighting on a suitable surface, germinates, it generally sends out a slender tube which either enters itself or sends down smaller tubes into the tissues of the host plant. In some cases the fungus can only enter through a wound, in others it forces its way through the unbroken surface of leaf, stalk, or other part of the host.

After a period the fungus forms spores which are often produced in special receptacles. Most fungi produce more than

one kind of spore. Each kind is as a rule specially suited to a particular set of conditions. For instance in the rainy season a fungus may produce a thin-walled spore capable of germinating at once but unable to withstand drought, while in the autumn the same fungus may produce spores which are specially adapted to resist drought and sunshine, and only germinate after a period of rest. In this manner the propagation of a particular species of fungus is carried safely through from one season to another and from one year to the next.

Parasitic fungi are common on all plants, but only occasionally do the attacks of an individual species assume an epidemic form. Other causes than the presence of an abnormal number of the spores of the fungus account for epidemics. They are usually brought about by the occurrence of atmospheric conditions exceptionally favourable for the infection of the plant by the fungal spores. Changes in other conditions also play a part. Epidemic attacks of fungus disease have occasionally been traced to the effect of alteration of soil conditions on the natural resistance of the plant. This change in soil conditions may have been brought about for instance by the introduction of badly balanced manurial mixtures or by the gradual reduction in the amount of some necessary soil constituents as the result of soil exhaustion.

It will be readily understood from the foregoing that knowledge of the life history of the fungus causing a disease is necessary in order that the method of treatment may be so arranged that the attack shall be concentrated on the fungus at a time when it is in the most vulnerable condition, and carried out in such a way that there is some chance of checking the disease effectively. It would be obviously useless for instance to spray a fungus with a contact fungicide during the period at which it is entirely within the tissues of the plant. It would be futile to attempt to eradicate a fungus merely by spraying the tea if the fungus is spending stages of its life on some other plant, possibly one found commonly in the jungle. It would be necessary in such a case either to treat the jungle plant as well as the tea or to remove the jungle plant, and it might be a sheer waste of time to attempt to deal with the disease by treating the tea bushes only.

There are many problems connected with the study of the life histories of fungi, and those of many of the fungi causing diseases of tea have not yet been solved. In formulating methods of treatment in such cases in the absence of evidence to the contrary it is presumed that the fungi resemble others of allied species and action is taken accordingly.

In the following note on the treatment of various diseases the life histories of the fungi causing the diseases are not discussed. Sufficient information is however given as to the nature of the damage caused by the most harmful fungi to enable planters to identify the disease. When this has been done planters are strongly advised to consult the references given in the paragraphs devoted to the particular diseases for further information. In order to simplify the practical operation of dealing with fungal blights the number of fungicidal mixtures recommended for the purpose of spraying has been reduced as far as possible.

What to do when an Outbreak of Fungus Disease is Discovered.

Always send specimens of any unrecognised disease to Tocklai at once with full particulars of soil, jat and age of tea, weather conditions during the development of the disease, extent of damage, any other relevant details. The disease may be doing little damage but under other conditions it may become serious. If the specimen is sent to Tocklai the department is able to investigate the disease and is in a better position to suggest remedies should the disease at any time become serious.

In the case of stem or leaf diseases.

1. Isolate the bushes concerned by preventing coolies, cattle, etc., from touching them. All the necessary cultivation, etc., should be carried out by special coolies, using specially marked implements. At the conclusion of the operations for the day the coolies and implements should be sprayed with lime sulphur solution on the spot so that the disease will not be carried about.

The lime sulphur solution does not injure the skin or clothing but should not be allowed to get into the eyes. The solution is also a cure for itch and various other skin diseases.

2. Pluck or prune off all the diseased portions and burn them on the spot. If they are too green to burn alone a little kerosine will help matters.

3. Spray the bushes thoroughly with a fungicide, *e.g.*, lime sulphur.

4. Repeat the plucking, pruning and spraying at intervals depending on the nature of the disease.

Where there are numerous outbreaks occurring at the same time, treat the small ones first, isolating the larger areas until time permits treatment to be carried out on them.

In the case of root diseases.

1. The areas containing the dead and dying bushes should be isolated and all the implements used in cultivation, etc., of such areas should be kept separate. There is no need to disinfect the coolies.

2. The edges of the large areas and all small areas should be dealt with first by digging out the dead and diseased bushes, taking great care to remove all the dead wood from the soil.

3. All the dead wood should be burned on the spot if possible. If it is not feasible it should be removed in old bags or baskets and burned elsewhere. Care should be taken to either burn the bags or baskets or disinfect them thoroughly with lime sulphur solution.

4. Watch for new outbreaks and deal with them at once.

5. Dig out all dead wood and manure the soil with suitable chemical manures before replanting.

In planting out be very careful to clear out all the dead stumps. This operation is costly but very desirable. Jacks are very useful for removing smaller trees and the large stumps may be used as centres for the burning of piles of wood collected round them.

SUGGESTIONS FOR THE TREATMENT OF CERTAIN FUNGUS BLIGHTS OF TEA.

Blister Blight.

(*Exobasidium vexans, Mass.*)

"Indian Tea Association, Scientific Department, Quarterly Journal," pt. IV, 1921, p. 209.

"Indian Tea Association, Scientific Department, Quarterly Journal," pt. II, 1922, p. 35.

Nature of damage.—The blight at first appears as round, translucent pale yellow sometimes pink spots on the leaf. As the disease progresses, these spots enlarge into white or pinkish convex warts mostly on the under-surface of the leaf. The opposite surface is pale green, yellow or pink with a concave depression. At a later stage these white convex warts shrink and darken into deep brown, almost black spots, which, dry up, sometimes crack and fall out leaving round holes in the leaf. The fungus produces two forms of spores. Only found on jungle at very high elevations, *e.g.*, Rhododendron forests.

Treatment.—All blistered leaves and also all leaves liable to attack should be removed and burned on the spot. Infected areas should be sprayed with either Lime sulphur solution or Burgundy mixture immediately after removing the leaves. Spraying of infected areas should be repeated when the new leaves appear. Heavy pruning should be carried out as early as possible. Heavy pruned or young tea should be protected by spraying.

The abandoned and unpruned seed trees should be thoroughly examined in the cold weather and all blistered leaves should be removed.

Copper Blight.

(*Laestadia camelliae* Cke. = ? *L. Theae* Rac.)

"Indian Tea Association, Scientific Department, Quarterly Journal," pt. III, 1921, p. 168.

Nature of damage.—In the early stage a coppery coloured sheen is formed on the under surface of leaves. The leaves then bend over with the underside outmost. This stage is succeeded by the formation of ill-defined patches of yellowish brown colour on the upper side which later on become better defined and darker and extend right through the leaf. Minute dots (pycnidia) appear scattered about in the centre of diseased patches (the spores produced inside the pycnidia are called pycnospores.) These patches finally become very brittle and frequently crack. When the spots become brittle and grey the second form of fructification appears as minute black dots (perithecia) similar to but smaller than the others.

Treatment.—Pluck off and burn all the diseased leaves. Spray with Lime sulphur solution. As the pycnospores develop fruits seven days after infection, it is necessary to keep the leaves protected by spray fluids for at least a week in order to kill the spores produced by the fungus which was developing in the leaves at the time the first application was applied.

Grey Blight.

(*Pestalozzia Theae*, Sawada.)

"Indian Tea Association, Scientific Department, Quarterly Journal," pt. IV, 1920, p. 152.

Nature of damage.— Leaves form grey patches (brown when young) on the upper surface, edges of which are sharply defined by a ring deep brown and may often be marked with concentric rings alternately light and dark brown.

Minute black dots (much larger than those of brown blight) are seen arranged in concentric lines on the upper surface near the margin of the diseased spot. Sometimes

they are scattered irregularly over both the surfaces of the spots. Some of the dots coalesce to form black crusts. Not common in the jungle but nearly allied species attack many jungle plants.

Treatment.—The same treatment as recommended for Brown blight should be carried out in this case.

Brown Blight.

(*Glomerella cingulata* (stonem) S. & v.s. = *Colletotrichum camelliae* Mass.)

"Indian Tea Association, Scientific Department, Quarterly Journal," pt. II, 1920, p. 37.

Nature of damage.—Forms patches on leaves yellowish to chocolate brown above and light brown below, edges of which are marked with a delicate zonation of narrow lines and darker bands. Minute black dots are seen arranged in concentric lines on both sides. On some of these spots may be seen milky or pinkish drops (masses of conidiospores). At a later stage the surface of these patches become grey and covered with black dots (perithecia). Common in the jungle.

Treatment.—If there are signs of a serious attack developing manure the soil with equal parts of nitrate of potash and nitrate of soda at the rate of say 1 cwt. per acre.

Rim Blight.

(*Pestalozzia palmarum*, *Alternaria sp.* and possibly other fungi.)

Nature of damage.—The margins of young leaves die as though scorched by a hot wind.

Treatment.—The life histories of the fungi causing this blight, have not been investigated sufficiently to warrant the suggestion of distinctive treatments. That suggested for Copper blight has been found effective in dealing with them also.

Red Rust.

(*Cephaleuros Mycoidea*, Kart.
Cephaleuros virescens, Kunze).

"Indian Tea Association, Scientific Department,"
Pamphlet No. 9, 1904.

Nature of damage.—Bush attacked by this disease posssses a number of variegated leaves—partly yellow, partly green.

Spots (in greater or less quantity) on stems are livid red or orange red, which, when held sideways between the eye and light will be noticed to consist of a multitude of filaments rising up like a tiny forest.

Bushes attacked by this fungus become non-luxuriant, non-yielding and ultimately die The disease is caused by an alga which is common everywhere, often allied with a fungus—as a lichen on stems and leaves in the jungle.

Treatment.—An application of a fungicidal solution such as Lime sulphur solution immediately after pruning will be found beneficial.

Thread Blight.

Nature of damage.—The fungus develops white strands of mycelium like threads which grow along the branches and spread out to form a white felt on the underside of the leaves. The diseased leaves turn brown (not black as in Black Rot), after some time the film spreads out and remain hanging to the bush suspended by white threads.

The threads and the films of the fungus can be peeled off from the stems and leaves when wet without difficulty. Common in the jungle.

Treatment.—Prune out the infected stems and spray with a fungicide such as Lime sulphur solution or 1% Burgundy mixture.

Improve drainage and remove excessive shade.

The Die-Back Disease.

"H"—Blight or Brown blight on stems.

(*Gloeosporium sp.*)

"Indian Tea Association, Scientific Department,
Quarterly Journal," pt. III, 1920, p. 37.

Nature of damage.—Green shoots attacked by this disease become brown at first and turn black later.

A few inches at the top of the shoots die back.

Fruit bodies are produced on the bark of the diseased portions. They are identical with those of Brown blight on leaves. Common in the jungle.

Treatment.—Bushes should be sprayed with Lime sulphur solution or 1% Burgundy mixture after removing all diseased shoots.

Attention should be given to drainage and manuring.

Tea Canker.

(*Nectria cinnabarina* (Tode) Fr.)

"Indian Tea Association, Scientific Department,"
Pamphlet A stem disease of tea, 1918.

Nature of damage.—Bushes attacked by *Nectria* become moribund but rarely die right out. The stem die back and the new shoots arising below become thin and weakly.

General appearance of the diseased bush is similar to that of tea badly attacked by Red rust.

The plants may form callosities.

Red fruit bodies and pink cushions are produced on diseased stems.

Found on certain trees, *e.g.* ***Alnus nepalensis*** (utis).

Treatment.—Remove trees (in the neighbourhood of tea) known to harbour the fungus.

Diseased bushes should be pruned at once to good wood and sprayed with a fungicide immediately after pruning.

The prunings should all be burned on the spot at once.

All the tea near the infected bushes should be sprayed immediately after each cold weather pruning every year until the disease has entirely disappeared.

Black Rot.

(*Corticium invisum.*)

"Indian Tea Association, Scientific Department, Quarterly Journal," pt. III, 1917, p. 80.

"Indian Tea Association, Scientific Department, Quarterly Journal," pt. III, 1918, p. 70.

Nature of damage.—The shoots and leaves are black when wet but resemble those injured by Brown blight when dry.

The dead leaves hang on although completely black and rotten.

The occurrence of dead leaves united in clusters of two or three or united to the stem by a weft of mycelium.

The spore producing areas have a white powdery appearance as if the wet surface of the leaf had been sprinkled with dusting powder. They are generally on the undersides of green leaves.

Treatment.—The diseased leaves and shoots should be removed and burned at once. The diseased plants and three rows of bushes all round the diseased ones should then be thoroughly sprayed with Lime sulphur solution. Spraying should be repeated a week or ten days later.

Select special coolies to work in the infected areas. Disinfect them and the implements, baskets, etc., with Lime sulphur solution at the end of each day's work.

Epiphytic Plants.

(Lichens, Mosses and Ferns.)

Nature of damage.—Lichens, mosses and ferns although rarely parasitic render their host plant unhealthy, by restricting the flow of sap. They also harbour parasites.

Treatment.—A thorough application of a caustic spray fluid made after pruning will be found sufficient to clean the stem.

Root Diseases of Tea.

Brown root-rot, formerly known as *Hymenochaete noxia*, Berk, now found to be *Fomes lamaoensis* Murr.

"Indian Tea Association, Scientific Department,"
Pamphlet No. 1—1918, Tea Roots, pt. II.

Nature of damage.—Roots are encrusted by a mass of sand, earth and small stones and this may extend up to the stem above ground level for several inches. The crust is formed of the mycelium of the fungus which is cream coloured at first but changes to brown sometimes black later on.

The wood of the root will be seen to be marked with thin russet-brown lines. Later on the wood between these boundary lines decays leaving a honey-comb structure, the bounding marginal portions being dark and hard and the rotting portions yellow and soft.

Treatment.—Isolate the dead and dying plants from their healthy neighbours by a trench deep enough to prevent the roots outside coming into contact with those within. Dig up the dead bushes and burn them. Remove all the pieces of root by pouring the soil through a coarse sieve. In the case of large areas start operation round the edges.

If the soil is acid the acidity should be removed by application of lime.

Charcoal Stump rot.

(*Ustulina zonata*, Sacc.)

"Indian Tea Association, Scientific Department,"
Pamphlet No. 1—1918, Tea Roots, pt. II.

Nature of damage.—Bushes attacked by this fungus present an unhealthy appearance for a week or two before their death.

A soft white plate ½-3 inches in diameter forms on the bark of the collar. This plate often bends away from the collar like a bracket. The colour changes to black later and small dots appear in lines over the surface. Then the plate becomes brittle like charcoal.

If this bark be removed the wood will be found covered with delicate white fans of mycelium which extend into the live portions of the tissues.

Treatment.—Remove carefully all dead and dying bushes and all dead wood in their vicinity. The remaining bushes should be carefully cleaned of all dead snags and the wounds painted with copper sulphate paste.

A heavy dressing of lime should be applied to the soil (minimum 10 maunds per acre).

Die-back.

(*Thyridaria tarda*, Bancr.)

"Indian Tea Association, Scientific Department,"
Pamphlet No. 1—1918, Tea Roots, pt. II.

Nature of damage.—Bush attacked by this disease die suddenly with all its leaves attached just as though it had been struck by lightning.

The roots appear quite normal externally, which, when kept for a few days, present a sooty appearance due to the growth of spores called pycnospores.

If the wood be cut away it will be found to be a greyish colour as if it had been dipped in blue-black ink and allowed to dry.

The fungus enters the bush through drying wound.

Treatment.—Dead bushes should be removed and destroyed. Apply 2 to 3 ozs. of nitrate of potash to the soil round each bush, showing signs of the disease. Prune all snags and paint the wounds with the copper sulphate paste.

Black Root-rot.

(*Rosellinia arcuata*, Petch.)

"Indian Tea Association, Scientific Department, Quarterly Journal." pt. I, 1918, p. 24.

Nature of damage.—The fungus generally attacks the bush at the collar completely ringing it. A swelling may be formed above the diseased portion. The fungus grows up along the stem to a height of about 6 inches, where, it forms a continuous sheet purple-grey at first and then black. It forms white threads smoky-black with age, which, adhere to the outside of the bark and penetrate here and there to form stars over the surface of the wood.

It produces two kinds of spores. The conidiospores are borne on short, erect, bristle-like stalks produced in clusters so as to give a velvety appearance to the surface. The ascospores are produced inside some round, black bodies in clusters, like grains of shot $\frac{1}{10}$ inches in diameter.

Treatment.—Dig out the dead bushes and burn them. Clean away jungle and lay bare the collars of all the surrounding tea bushes.

Fork 2 lbs. of slaked lime into the topmost 6 inches of every square yard of soil in the infected area.

Improve drainage if necessary.

Violet Root-rot.

(*Sphaerostilbe repens*, B. & Br.)

"Indian Tea Association, Scientific Department," Pamphlet No. 1—1918, Tea Roots, pt. II.

Nature of damage.—Bushes attacked by this fungus look sickly. The roots present a water-logged appearance and also have a peculiar smell something like vinegar.

The wood is violet bluish colour at first, which disappears when dry. The bark is a violet colour. Under the bark thick strands (2-5 mm. across) of mycelium radiate star-wise over the wood. These strands are orange when young changing to pinkish-purple later.

Red fruit bodies resembling those of *Nectria* are formed.

Treatment.—The patch of sickly bushes should be enclosed by a trench deep enough to isolate the roots of the diseased bushes from those of healthy ones.

All dead wood and dying bushes should be removed and destroyed and drainage improved.

A heavy dressing of lime (20 to 30 mds. per acre) should be applied to the soil.

GENERAL TREATMENT.

In the past, few attempts have been made to combat a pest or blight until it assumes an epidemic form. A general treatment for the removal of organisms which interfere with the growth of the tea plant is a desirable addition to the routine on most gardens. Although such treatment would be more particularly useful in dealing with vegetable organisms it would also affect a number of important animal pests. The enormous losses due to minor blights, each not sufficiently severe by itself to warrant special treatment, have been almost entirely overlooked. The blights which attack young leaves may have received attention on some gardens ; but the numbers of blights which are common on the leaves and stems below the plucking level have in the majority of cases been passed over as causing very little harm. The loss of the older leaves is a natural process—nature's way of removing waste products from the plant—but the premature death and removal of leaves and shoots even though they be too old for tea manufacture, interferes with the health of the plant and reduces the out-turn. Besides organisms actually parasitic on the plant there are others whose presence is undesirable. For instance lichens, mosses, and ferns which may be found on almost any tea bush. They are rarely parasitic themselves ; but they encumber the stems thus restricting the flow of sap ; they clog up the stomata, interfering with respiration and transpiration ; and they also frequently form excellent harbouring places for harmful pests and blights. The good health of the tea plant does not solely depend on its freedom from injurious organisms. The treatment of pests and blights must in all cases be merely supplementary to the other necessary operations of cultivation, manuring, etc. There are, however, many gardens, and their number is increasing rapidly, where the addition of such a general treatment to the routine would be profitable.

In the cold season the tea plant is resistant to spray fluids of much higher concentration than those which may be safely applied

in the rains. Many of the organisms which it is desired to remove are also specially resistant during the former season. As a general rule therefore solutions for winter spraying need to be more concentrated than those employed during the rains.

In most tea districts there are in each year often two rainy periods separated by an interval of dry weather. During the early rains the pests and blights which have been dormant in the cold weather renew their activity and their ravages are in general specially noticeable during the succeeding dry spell. This dry period is the most convenient time for the application of hot-weather spray fluids. Bordeaux emulsion and lime-sulphur solution are suitable. A second rains application will rarely be found necessary where the previous applications have been carefully made.

SPRAY MATERIALS.

It is considered unnecessary to give in this pamphlet details with regard to the preparation of all the numerous insecticidal and fungicidal mixtures which have been and are being tried, and in the following notes are included only those which are at present considered likely to be most satisfactory.

It is impossible to make a definite distinction between fungicides and insecticides because many spray fluids are both fungicidal and insecticidal, but the spray materials described are discussed, for the sake of convenience, in alphabetical order and may be classed as follows :—

Insecticides.

Poison insecticides.

Lead chromate.

Contact insecticides.

Sulphur.
Lime-sulphur solution.
Potassium sulphide.
Emulsions.
- Kerosine emulsion.
- Crude oil emulsion.
- Bordeaux emulsion.

Rosin.
Soap.
Caustic soda.

Fungicides.

Bordeaux mixture.
    Bordeaux paste (Woburn).
    Bordeaux emulsion.
Burgundy mixture.
Sulphur.
    Lime-sulphur solution.
    Potassium sulphide.
Caustic soda.
Lime.

Practical hints of a general nature regarding the preparation of spray fluids will be found on page 60.

BORDEAUX MIXTURE.

This spray fluid was discovered about thirty years ago by a chance observation made on vineyards near Bordeaux. Lime coloured with a little copper sulphate was used to spray vines growing near roads in order to prevent passers-by from stealing the grapes. It was observed that those vines which were treated in this way were healthier and more productive than the remainder. Millardet and other French scientists made enquiries into the cause of this phenomenon and proved that the benefit was neither due to the lime nor to the copper sulphate but to the substances formed by the combination of the two. Although the mixture of lime and copper sulphate has been recognised as the best fungicide for general use since then, its action was not explained for many years.

The Duke of Bedford and Spencer Pickering have recently made a study of the reactions of copper sulphate with lime, and they published the results of their investigations in the 8th and 11th reports of the Woburn Experimental Fruit Farm. They discovered that the efficiency of the mixture depends on the formation of a definite chemical compound and that any excess either of lime or of copper sulphate interferes with the fungicidal action of the mixture. They ascertained that if certain definite proportions of the copper sulphate and lime are employed the fungicidal properties of the mixture are increased considerably. These

investigators arguing from theoretical considerations assumed that the strength of the mixture made according to their formula would be 2½ times that of ordinary Bordeaux mixture. They recommended the following formula :—

Dissolve 6 lbs. 6½ oz. of crystallised copper sulphate, by suspending it in a piece of sacking, in two or three gallons of water in a wooden or earthenware vessel. Take about three pounds of good quicklime and slake it in a little water, then put it into a tub with 120 gallons of soft water. Stir the lime and water, then leave it to settle until the liquid is quite clear. Run off 86 gallons of the clear lime water and mix it with the copper sulphate. Make up to 100 gallons with soft water.

Later research showed that other chemical actions took place which still further increase the efficiency making it at least twelve times that of ordinary Bordeaux mixture. The following formula was therefore recommended :—

Copper sulphate ...	...	...	1¾ lbs.
Lime water ...	...	..	17¾ gallons.
Water to make up to	...	...	100 „

Dissolve the copper sulphate separately in about one gallon of water.* Put about one pound of quicklime previously slaked into a tub with about 25 gallons of water ; stir this up and then leave it to settle. As soon as the liquid is quite clear pour off 17¾ gallons into the solution of copper sulphate. Add the extra water required to make the whole up to 100 gallons. As the lime-water may vary a little in strength it is necessary to test the mixture to make sure that there is sufficient lime to combine with all the copper. Therefore, before adding the extra water, ladle out a little of the mixture and add one or two drops of it to a weak solution of potassium ferrocyanide in a white saucer. If there is any brown colouration it shows that there is an excess of copper. A little more lime water must then be added and the test repeated. The old method of

* For the proportions of copper sulphate crystals which will dissolve in water at different temperatures see Appendix on page 75.

A table for determining the strengths of copper sulphate solutions by means of their specific gravities is given in the Appendix on page 73.

testing with a clean knife blade, seeing whether it becomes stained with copper on being placed in the solution, is unreliable.

The preparation of Bedford and Pickering's mixture demands more care than is usually exercised in the preparation of ordinary Bordeaux mixture, but the advantages possessed by the spray fluid are so marked that it is well worth while to go to the extra trouble in its preparation. The cost of materials is about one-twelfth of the amount required for the ordinary mixture. The mixture made according to the old formula does not exert any fungicidal action until some considerable time after application while that made according to the Woburn formulae comes into action at once.

An important point to remember in the preparation of Bordeaux mixture is that the precipitate should be as finely divided as possible. Experiments were carried out by the same investigators to determine the method of mixing the chemicals which would result in the formation of a mixture composed of finest particles. It was found that the desired result was obtained by mixing the copper sulphate in a strong solution with lime in a very weak solution. If the best results are desired the instructions given for mixing of the chemicals should be strictly adhered to. Various practical suggestions as to the preparation of spray fluids will be found on page 60.

The investigators who discovered the new formula for the mixture realised that in some cases the careful supervision essential to its successful preparation was unobtainable, and they prepared a similar product which may be stored in a condensed form. This has been placed on the market as **Woburn Bordeaux Paste.***

The Agents in India are Messrs. Shaw Wallace & Co., Calcutta.

The use of this paste is recommended on gardens where it is impossible to obtain supervision necessary for the accurate preparation of the Woburn Bordeaux mixture.

The paste has a bluish green colour, but it does not leave so bright a deposit on the leaves of bushes as does Bordeaux mixture

* Some difficulty has been experienced in rendering this substance resistant to the action of the Indian climate, under the effect of which it tends to decompose. Intending purchasers are, therefore, advised to ascertain from the sellers whether fresh stock is obtainable before ordering their supplies.

prepared according to the old formula. Its efficiency however is greater.

Bordeaux mixture is one of the best fungicides at present discovered. Besides killing the fungus blights it acts as a general tonic. It also to some extent protects plants from the attacks of insects.

BURGUNDY MIXTURE.

This mixture has some advantages over Bordeaux mixture. It is easier to prepare and the precipitate is somewhat finer. It has been found preferable to Bordeaux mixture for use on tea gardens.

To make 50 gallons 1% Burgundy mixture dissolve 5 lbs. of crystallised copper sulphate by suspending it in a piece of sacking in two and half gallons of warm water (if required immediately). If cold water is used the copper sulphate may be left to dissolve overnight.

In the same way dissolve 2·3 lbs. of Soda ash.

Add the soda ash solution gradually to the copper sulphate solution, stirring all the time, until the mixture becomes neutral. This can be tested with litmus paper. The solution should be either neutral or very slightly alkaline but never acid. It is necessary to prepare this mixture in wooden, copper or earthen vessels. The soda ash attacks iron a little but not sufficiently to make any serious change in the solution.

The addition of the above mixtures will make 5 gallons concentrated mixture which when diluted to 50 gallons will be 1% Burgundy mixture.

BURGUNDY MIXTURE WITH RESIN.

Washing soda	1 lb.
Resin (common resin or colophony) ...	2 lbs.
Water	1 gallon.

Boil the water, then add the soda. When dissolved, add the resin and boil for about an hour, stirring continually.

Add this, when cool, to Burgundy or Bordeaux mixture at the rate of one gallon to the every 24 gallons of Burgundy or Bordeaux

The addition of this solution makes the mixtures stick to the leaves better.

It also overcomes the tendency to form drops and the mixture spreads out as a thin film.

CAUSTIC SODA.*

(Sodium hydrate, hydrate of soda.)

Caustic soda solution is very useful as a winter spray fluid. It softens the bark and cleans off lichens, mosses, and other epiphytes. It may also be used as a contact insecticide chiefly against scale insects.

The strength most suitable is :—

(1)

Caustic soda (98% purity)	2 lbs.
Water	10 gallons.

The Caustic soda in powder form should be stirred into the water. Care should be taken that it does not cake at the bottom of the vessel and that it is mixed with the water slowly. If a small quantity of water comes into contact with a large quantity of caustic soda great heat will develop.

Caustic soda solution of the same strength as the above mixture may be made by mixing together the correct amounts of carbonate of soda solution and lime. The carbonate of soda combines with the hydrate of lime forming hydrate of soda and carbonate of lime. Carbonate of soda may be obtained as either crystals or powder. The crystalline form is commonly known as washing soda. A crude form known as soda ash is also available. The crystalline form contains water in combination. This water is not present in the powder or ash form, two different formulae are therefore necessary.

(2)

Crystalline carbonate of soda (washing soda)...	7 lbs.
Quicklime	2 ,,
Water	10 gallons.

* For tables showing the strengths of Caustic soda, etc., see Appendix on page 72.

or (3)

Dry carbonate of soda or soda ash			...	2½ lbs.
Quicklime	...	...	...	2 ,,
Water ...	...	...	...	10 gallons.

The efficacy of the mixtures prepared according to the respective formulae is about the same. A little slaked lime may be added to the first mixture in order to make a spraying solution which leaves a white coating on the treated bushes so that the work may be more easily checked. In the case of the two latter solutions the precipitate of carbonate of lime formed when the mixture is made answers the purpose.

Caustic soda should be stored carefully because it absorbs water and carbonic acid gas from the air very readily. Vessels in which it is kept must be kept tightly closed and solutions of it should be exposed to air as little as possible.

EMULSIONS.*

A number of spray fluids, used chiefly as insecticides, contain kerosine as their principal ingredient. Plain undiluted kerosine is sometimes used, but is not generally so satisfactory as when mixed with other substances. Kerosine is an oil and will not mix freely with water or aqueous solutions. If kerosine be squirted into water it breaks up into small particles which, however, soon collect together to form a layer of oil, which floats on the surface of the water. In order to keep these small particles of kerosine suspended in the water it is necessary to introduce substances which prevent their coalescence, forming a permanent emulsion. Soap is the substance most commonly used for emulsifying kerosine in water.

Kerosine Emulsion.—One of the best formulae for this insecticide is the following :—

Kerosine oil	...	...	...	2 gallons.
Soap ...	...	...	...	½ lb.
Water ...	...	...	...	20 gallons.

* Soft water gives the best results with emulsions and soap solutions, and tank water should be used wherever possible.

The soap is first dissolved in 1 gallon of boiling water, the kerosine oil is added and the mixture violently agitated for ten minutes. One of the best ways of agitating the liquid is to keep pumping it into itself with a syringe (fitted, preferably, with a rose jet). Keep the mixture heated while agitating it. When the mixture has been thoroughly agitated, add the remainder of the water, and it is ready for use.

An oil suitable for the preparation of emulsions has recently been placed on the market by the Assam Oil Company, Digboi, Assam, under the name "Insecticidal oil." It costs 4 annas per gallon for quantities not less than 10 gallons supplied in customers' own receptacles.

Crude Oil Emulsion.—The emulsions of the heavier unrefined petroleum oils have somewhat stronger and more lasting insecticidal properties than those of the refined kerosines and they may be used in practically all cases where kerosine emulsions are used. They have, however, a greater tendency to burn the bushes, and weaker emulsions are, therefore, recommended. These emulsions consist mainly of mixtures of petroleum oil and soft soap in varying percentages, with the addition of sodium carbonate in some cases. They are difficult to prepare, but there is upon the market a preparation, suggested by Lefroy, sometime Imperial Entomologist to the Government of India, sold under the name of "Crude Oil Emulsion," and obtainable from Messrs. Bathgate & Co., Calcutta. This preparation contains 80% of crude oil and 20% of whale oil soap. It may be used at a strength of 1 gallon to 50 gallons of water. The spray fluid must be thoroughly mixed with the water to form a milky solution. This is best effected by thoroughly mixing the crude emulsion with a little water and adding the rest of the water to this.

The following mixture has been used successfully against Red Spider in Behar:—

Crude oil emulsion ...	...	... ½ pint.
Flowers of Sulphur...	...	... 2 ozs.
Water	...	... 4 gallons.

Crude oil emulsion is sold at Rs. 6-8 per 5-gallon drum.

LEAD CHROMATE.

This insecticide is recommended for use against tea pests which require to be treated by means of a contact insecticide, as it possesses the advantages of being non-arsenical, fairly cheap, and of having no deleterious action on the bushes, while its yellow colour renders it easily visible. It sticks to the foliage well, and although not so poisonous as arsenical mixtures, is yet excellent for keeping away plant feeding insects.

This substance is obtainable from Messrs. D. Waldie & Co., Konnagar, Calcutta, in two forms, a dry powder or a paste, the latter being a mixture containing 60% of lead chromate. It is sold, in lots of 100 lbs. in 20 lb. tins, at Rs. 1-6-6 for the powder and Rs. 0-12-6 for the paste, per lb. The paste, when fresh, makes a better spraying mixture than the powder, but is apt to cake if not kept carefully. Lead chromate is used at a strength of 1 lb. of the powder, or 1½ lbs. of the paste, in 60 gallons of water. With a four-gallon knapsack machine the spray fluid may be very conveniently prepared by mixing 1 oz. of the dry chromate or 1½ oz. of the paste with a spraying machine full of water.

The most efficient lead chromate wash is prepared as follows :— Dissolve 1 lb. of lead acetate in 55 gallons of water. Dissolve ½ lb. of potassium bichromate in 5 gallons of water, and add it to the solution of lead acetate. Lead chromate is produced in a fine state of division, and the mixture may be sprayed on to the bushes just as it is. 1 oz. of lead acetate and ½ oz. of potassium bichromate are the quantities required per four-gallon spraying machine.

LIME.

(Calcium oxide.)

Lime is frequently used as a winter application. To be effective it must be prepared so as to contain no less a percentage of lime than that represented by the following formula :—

Lime	20 lbs.
Water	10 gallons.

It is not so effective as caustic soda and it is much more difficult to apply because the solid particles clog the spraying machinery.

ROSIN.

Rosin dissolved in soda forms spray fluids which are useful against soft-bodied insects such as tea aphis, and scale insects.

A simple, yet effective formula for scale insects is :—

Rosin	... 8 lbs.
Caustic Soda ...	.. 1 lb.
Water to make 30 gallons ...	... 30 gallons.

To prepare the solution the caustic soda is dissolved in one gallon of water. To half of this solution the rosin is added, and boiled until the rosin is dissolved. The remainder of the caustic soda solution is then added gradually, and the whole boiled, with constant stirring, until it will mix with the cold water to form a milky solution. Add water to make 30 gallons, and the mixture is ready for use.

Lefroy recommends the following formula for use against thrips :—

2 lbs. rosin.
1 lb. washing soda.
2 gallons water.

Boil the rosin and washing soda in just enough water to cover them until both are dissolved. Add the remainder of the water a little at a time, and boil until the mixture becomes clear, and will mix with water to form a clear solution. To this stock solution six gallons of water may be added to make a strong wash, ten gallons to make a normal wash. The stock solution will keep, so that if desired a quantity may be made up and diluted as required.

SOAP.

Soap possesses valuable properties as an insecticide for use against small soft-bodied insects, and is one of the constituents of most effective emulsions.

Antram's formula is :—

Soap	... 1 lb.
Water	... 20 gallons.

SULPHUR.

Sulphur has long been used on tea gardens for the treatment of Red Spider. The three principal forms in which it may be obtained are :—

1—flowers of sulphur—this is a finely divided form produced by solidification of sulphur from the state of vapour :

2—ground sulphur—which is obtained by the pulverisation of sulphur : and

3—precipitated sulphur—prepared by precipitation from solutions of poly-sulphides and obtained on a large scale from material which has been used in gas purifiers.

Ground sulphur is now-a-days prepared in such a fine state of division that it adheres quite as well as flowers of sulphur or precipitated sulphur ; it is cheaper, and less liable to have a deleterious action on the bushes. It may be applied alone or mixed with equal quantities of lime or soot. The usual method of applying the insecticide is by dusting it on to the bushes through coarse bags in the early morning, while the dew is still on the leaves, but the bushes may be covered much more effectively by means of a powder sprayer. The operator should always stand with his back to the wind when dusting sulphur. Complaints have been made of late years that sulphur, as a remedy for Red Spider, is not as effective as it used to be, and yet samples tested by this Department were found to be of high purity. This question is discussed under Red Spider.

Lime-Sulphur solution is best prepared, for insecticidal purposes, according to the following formula :—

Quicklime	...	...	..	20 lbs.
Sulphur	...	...	...	22½ „
Water ...	...	...	...	50 gallons.

The lime should be put into a drum holding 50 gallons and slaked by adding water gradually. When it is fully slaked, add about 30 gallons of water, and bring to the boil. When it is

PLATE VI.

Pressure Sprayer.

With separate pump.

The "Alpha" Pressure Knapsack Sprayer
improved pattern.

boiling add the sulphur gradually, stirring vigorously during the whole time, and when all the sulphur has been added pour in boiling water to the 50 gallons mark. Boil for an hour longer, keeping the volume at 50 gallons by adding *boiling* water. This gives the stock-solution, which, when cool, may be diluted with 10 or 12 volumes of water and used immediately. It is a useful spray fluid for Red Spider.

Great care must be used in its preparation, and if it be desired to keep the stock solution, it must be stored in full, air-tight vessels, or, if the vessel is not full, with a layer of oil on the surface.

The best lime-sulphur solutions are those prepared on the garden as required, if they have been made properly, but experience shows that these home-made solutions are of very variable efficiency, and stock solutions may be bought ready made, which only need to be diluted with the requisite amount of water to be ready for use. Such stock-solutions are obtainable on the Calcutta market. The same care must be observed in storing them as in the case of the home-made stock solution. The composition of these solutions sometimes varies. In appendix 5 will be found a table which will help in deciding the dilution at which the stock solution should be used for spraying bushes in leaf.

Lime sulphur solution should not be stored in copper vessels, or sprayed on to the bushes from copper spraying machines. Great care must be taken to see that all spraying machines are thoroughly cleaned out after use.

Potassium Sulphide.—This substance is useful both as an insecticide and as a fungicide. It makes a valuable spray fluid for use against Red Spider and other mites. It is at present difficult to obtain in India, but Messrs. Shaw Wallace & Co., of Calcutta, are, it is believed, about to place the commercial form, which is known as liver of sulphur, on the Calcutta market. This commercial form is a mixture of several chemical compounds, and is a very variable in composition. Its efficiency depends on the proportion of sulphur which it contains in the

form of sulphide. Good samples should contain between 25 and 30% of "sulphide" sulphur. Potassium sulphide should be used, against Red Spider and other mites, at a strength of 3 lbs. to 100 gallons of water, *i.e.*, roughly, 2 ozs. to a 4-gallon spraying machine.

When using potassium sulphide the following points should be carefully noted :—

1. This substance must always be kept in air-tight tins or jars. It should not be kept in copper vessels, nor should the solution be sprayed on to the bushes from copper machines. Spraying machines used for potassium sulphide should be made either of galvanised iron, brass alloy, or of steel lined with bitumen mastic.
2. The spray mixture should always be made up as required for use.
3. Potassium sulphide has a tendency to scorch the leaves and should, preferably, be applied only on a dull day, or towards evening.

PLATE VII.

Pressure Sprayer.

With separate pump.

Simplified sectional diagram of a Battery Knapsack Sprayer—

a point of attachment of delivery tube.

b point of attachment of force pump when charging machine.

c floating ball valve which retains the air when liquid is exhausted.

d ball valve which closes the tube leading to *b* when the machine is charged.

SPRAYING MACHINES.

SPRAYING MACHINES FOR FLUIDS.

There are many classes of spraying machines ranging from hand syringes to huge power-sprayers worked by an engine of several horse power. Of these the one most suitable for use on tea gardens under present conditions, is the knapsack class. This class of machine is one which is designed so as to be carried on the shoulders and holds 3 or 4 gallons of spray fluid. There are many different types on the market. In all of these the four important parts are :—

1. **The container**, or vessel which holds the spray fluid.
2. **The pump**, by means of which the fluid is ejected from the container.
3. **The nozzle**, by means of which the stream of fluid ejected from the container by the pump is broken up into a mist of fine particles, so as to ensure a thorough wetting of the foliage with as little waste of material as possible
4. **The delivery** tube, which conveys the stream of fluid from the container to the nozzle.

1. **The container** consists of a metal tank, and holds the spray solution. It should be strong, especially in the case of pressure sprayers, but should be as light as possible consistent with the necessary strength. Containers (in fact, all metallic parts of a spraying machine) are constructed of different materials, and the choice of materials depends on the purpose for which the machine is to be used. Some of the commoner materials used are :—

(*a*) COPPER—may be used for the construction of machines in which Bordeaux mixture, oil emulsions, lead chromate, soda, soap, and rosin solutions are to be used. Lime sulphur or potassium sulphide solution should not be used in them.

(*b*) BRASS ALLOY—may be used for the construction of machines in which lime-sulphur, and potassium sulphide solution, as well as Bordeaux mixture, oil emulsions, etc., are to be used. Machines made of brass alloy are liable to be corroded however by soda solution and should be very carefully cleaned out immediately after use.

(*c*) STEEL—lead-coated with a lining of bitumen mastic—this lining prevents any of the above mentioned solutions from corroding the metal, and machines made with such a lining may be used for all of them.

(*d*) GALVANIZED IRON—continuous pumping machines are sometimes made of this material. These machines may be used for lime-sulphur and potassium sulphide solution, and for any of the oil emulsions or soap solutions ; but not for solutions containing copper.

The hole through which liquid is poured into the container is sometimes closed by a lid which clamps down on to a rubber washer, and sometimes by a screw which screws down into a leather washer. These washers are perishable, particularly so in a hot damp climate and require to be renewed occasionally. Every imperfect washer means leakage, with consequent loss of pressure.

2. **The pump** is a part of the machine which often gives trouble, and types of pumps in which the valves are of metal are most satisfactory. The plunger leather will need occasional renewal. In some machines the pump is outside the container. This is an advantage, because thus the fluid does not come into contact with the pump. In others it is inside. In some forms the pump pumps air directly into the fluid. This is the case in the self-contained pressure type of machines. In most continuous-pumping machines, however, in order to maintain a steady pressure, air is pumped into a pressure-chamber, and not directly into the fluid. Sometimes an agitator, to keep solids in suspension, is attached to the machine, in which case it is worked by the pump-handle.

3. **The nozzle.**—The smaller the amount of a fluid required to cover a certain area of foliage the greater is the efficiency of a

spray jet. In order to effect this the particles of fluid of which the spray is composed should be as small as possible. The breaking up of the fluid into small particles is effected by means of a nozzle. It is therefore extremely important from the point of view of economy that the right kind of nozzle should be used. Various principles are employed in designing and constructing them, so as to bring about the requisite disintegration of the fluid. The following are examples of some of the principles employed :—

(*a*) Spray produced by the margins of the orifice. The simplest form of spray jet is made by pinching the end of a pipe through which water is being forced. The friction of the water against the margin of the orifice causes the water to break up into small particles. The fineness of the spray is influenced by altering either the size of the aperture or the pressure of the liquid.

(*b*) Spray produced by obstructions. When a rapidly moving liquid impinges upon a solid body it breaks up into spray. This principle is used in the construction of some forms of spray nozzle. In this type of nozzle a spherical body is usually held close to the aperture from which the liquid is emitted.

(*c*) By far the most common form of nozzle depends upon the principle of centrifugal force. The liquid is given a rapid rotary motion just before it escapes. As soon as it escapes by reason of its rotary motion, it flies into small particles producing a very fine mist-like spray. The Vermorel nozzle was one of the earliest nozzles of this type and for many years was the most satisfactory one on the market. Nozzles of this type frequently clog when used with fluid containing solid particles. The original pattern has now been improved, and several types are self-cleaning. (See Plate I.)

Experience has shown that nozzles containing springs, swivel joints, etc., soon get out of order when used by tea garden coolies

and taken all round the most satisfactory type of nozzle at present on the market is the one shown in the plate No. II. This nozzle is sold under various names by a number of firms.

4. **The delivery tube** consists of two parts, a brass tube, known as a *lance*, to one end of which the nozzle is attached and a flexible tube, usually of canvas, reinforced externally by a wire spiral, connected at one end to the container, and at the other to the lance. All the connections should be kept in good order, so as to prevent leakage. The lance should have a bend at the end near the nozzle, so that the bushes can be sprayed from below without any difficulty, and should be provided with a tap. The spring tap which opens when the hand is closed over it and the lance, and closes when the pressure is released, is the most convenient type to work with. The tap must be kept in good order, or leakage will occur, which will result not only in loss of part of the solution, but, in the case of caustic solutions, in injury or soreness of the operator's hand. It is found in practice that in the case of machines in which the delivery tube is attached to the top of the container, and is brought over the operator's shoulder, the canvas tube requires renewal less frequently than in the case of machines in which this tube is attached to the bottom of the container, as it is kept clear of the bushes.

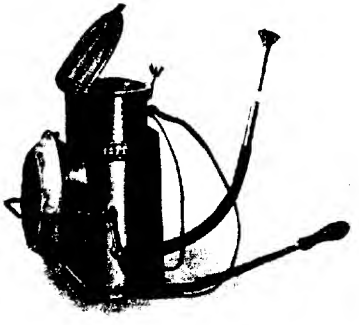
Experience has again shown that the simple types are the best for use on tea gardens. Springs, etc., all get out of order and the best tap for use with sprayers is the gland tap. This type of tap has no nuts to fall off and any leakage can be prevented by keeping the gland well packed. A very useful addition to the lance is the *strainer rod* supplied by the Four Oaks Spraying Machine Co. This prevents any grit reaching the nozzles. It is easy to clean and gives no trouble.

THE I. T. A. FOUR-NOZZLE ATTACHMENT.

An attachment which was designed by the Mycological department some years ago has now been placed on the market by the Four Oaks Spraying Machine Co. This arrangement is very useful for spraying unpruned and light pruned tea. Plates No. III and IV explain themselves.

PLATE VIII.

Powder Sprayer.



The "Little Wonder" Knapsack Powder Sprayer.

Nozzle of the special delivery tube supplied with the "Little Wonder" Knapsack Powder Sprayer.

Knapsack Powder Sprayer in use

KNAPSACK SPRAYERS

There are two principal types of knapsack sprayer, the *continuous-pumping type*, in which the operator must work the pump all the time he is spraying, and the *pressure type*, in which, when charging the machine, air is pumped in to a sufficient pressure to expel the whole of the contents, so that the operator does not have to work the pump while applying the spray fluid to the bushes.

1. **The Continuous-Pumping Knapsack Sprayer** is the older type. Its principal drawback lies in the fact that the attention of the operator is divided between pumping and directing the spray, and that the former operation is very tiring. Both hands are fully occupied with the machine the whole time. (See plate No. V.)

2. **The Pressure Knapsack Sprayer**, in which the necessity for pumping while spraying is done away with, has been recently put upon the market. In these machines the pumping is done before the actual operation of spraying commences, and the operator has one hand free to part the bushes, or to help himself up or down hill, etc., without having to cease operations while doing so which is a great advantage. This type of machine is rapidly superseding the older continuous-pumping type, the cheaper makes should be avoided however as they are not very satisfactory. These machines are made in two forms. In the first form a pump is attached to each machine, in the second the pump is separate and one pump may be used for several machines. (See plates Nos. VI & VII.)

Battery Sprayers.—The latest sprayer is a modification of the second type of pressure sprayer. The outfit includes a strongly made central charge pump and a convenient number of containers. The standard type charge pump is fitted with two cylinders, a large one for air and a smaller one for liquid. There is a long lever which can be connected to either cylinder. The machine is fitted with a pressure gauge. The containers are simply constructed and fitted with ball valves. (See plate VIII.) At the commencement of operations each container is charged with air to 30 lbs. pressure by means of the large cylinder on the charge pump. This cylinder is then disconnected and the other brought into operation. The machines are then charged with fluid until the gauge registers 70 lbs. When charged to 70 lbs. a container holds $3\frac{1}{2}$ gallons of fluid. When the fluid is discharged

the air is retained under pressure by the ball valve and to re-charge it is only necessary to pump in liquid. This is a much more efficient method than that involving the repeated pumping of air. A special small type of Battery pump is made for use in hilly districts where the standard model would be too cumbersome for transport up and down the steep and narrow paths.

DUST SPRAYING MACHINES.

The successful use of dry powders such as flowers of sulphur against pests and blights has led to the invention of numerous machines for their distribution. Knapsack machines of this class are usually cumbersome, and awkward to use, but until a better type of machine is devised one can recommend no other. They consist of a container, to hold the powder, a leather bellows and a delivery tube of special construction. They are usually fitted with a sieve plate, to ensure that only fine particles of powder go out in the spray, and with a series of grinding plates, to break up large particles worked by the handle which works the bellows. (See Plate IX.)

Large power machines have recently been placed on the market and their manufacturers claim that the application of suitable powders with such machines is just as effective as fluid and 50—70% cheaper. It is stated that certain machines are capable of treating 50—60 acres of fruit trees per day. The machines are costly and so far no experiments have been made with them in tea. In the case of many spray fluids the water is merely an agent for the distribution of the chemicals. If air can be used as effectively a great deal of labour would in all probability be saved.

A suitable brush for painting cuts and applying caustic soda solutions is made as follows :—

Take a piece of bamboo about 1½ inches in diameter and 2 feet long, having a knot at each end. Bore out the knots with an auger. Take a piece of tow of sufficient size, tie a piece of wire round the middle leaving an end long enough to go the length of the bamboo and project at the other end. Thread the wire through the bamboo and pull the tow into position. Fix the loose end by means of a wooden plug driven into the hole.

ORGANISATION.

All garden work is now carefully considered, before being put into execution, and spraying requires as much planning out as any other garden operation. As the treatment of large areas is a recent innovation and is not yet thoroughly understood by many planters here is special need for care in making arrangements beforehand. Every detail should receive attention so that there may be no waste of time or money. The slow progress made in the treatment of pests and blights by spraying has been partly due to the lack of careful organisation of the operations. Too often the details of what is after all rather complicated work have been left to garden sirdars with the result that the spraying has been an expensive failure. However effective the spray fluid may be, however efficient the spraying machines, the work of spraying is not likely to be a success unless it be organised with intelligence. Gardens vary so much that it is impossible to lay down hard and fast rules for every case but the following notes on the various details of organisation may furnish managers with ideas for carrying out the operations on their own gardens. They are based on observations made by the authors in the various tea districts and are intended to convey suggestions only :—

DIVISION OF LABOUR.

Experience on many gardens has shown that it is advisable to divide the operation of spraying as follows :—

Preliminary	...	1. Choice of spray fluid and decision as to the best time to spray.
		2. Calculation of materials, labour and time required to spray the area in question.
Actual Procedure		3. Weighing out of chemicals and preparation of stock solutions.
		4. Distribution of water and chemicals or stock solutions.
		5. Application of spray fluid to the plants.

The first two operations are matters for the manager. Each of the three last divisions is best carried out by a separate staff working more or less independently. The weighing out of chemicals and the preparation of stock solutions is generally carried out at the factory. Having ascertained the number of bushes which can be sprayed with a machine charged once, it is possible to arrange distribution centres so that whenever a machine is emptied there is a fresh supply of spray fluid in such a position that no time is lost in refilling it.

A gang of coolies, distinct from those who are actually spraying, should take the chemicals or solutions from the factory, where they have been prepared by another set of coolies, to these centres of distribution, carry the water, and prepare the fluids ready for the use of the gang of coolies working the machines. Sometimes it is convenient to prepare the fluids at the factory and carry them in barrels or tanks to the centres, but in the majority of cases water can be obtained from nullahs or drains and the cartage may be reduced by making up the fluids in the field. The chemicals may be weighed out at the factory in quantities depending on the capacities of the barrels or tanks in which the solutions are prepared. The weighed quantities of chemicals may be distributed to the centres in packets or bags. In the case of chemicals which take a considerable time to dissolve such as copper sulphate, it is advisable to prepare strong standard solutions at the factory, and measures which contain the correct quantity of standard solution for the preparation of the fluid for each receptacle may then be made use of.

PRELIMINARY CALCULATIONS.

Estimation of chemicals required.—Before commencing operations it is of course necessary to estimate the quantities of solution and hence the weight of chemicals required. It is not possible to give figures as to the volumes of solutions required per acre as the size of the tea bushes under different conditions and at different stages of growth varies so much, and this influences the amount of spray fluid required to spray a certain acreage. The simplest way of obtaining accurate information on the subject is to find out by

PLATE IX.

experiment how many bushes can be sprayed with one charge of fluid. It is then a simple matter to calculate the number of gallons of fluid required per acre.

The following table may be taken as a rough guide :—

Unpruned well grown tea—250 gallons per acre. High pruned well grown tea—150-200 gallons per acre.	with I. T. A. 4 nozzle attachment.
Low pruned tea—100-150 gallons per acre. 1 year old well grown seedlings—40 gallons per 1,000 plants.	with ordinary single-nozzle.

Frequently crude chemicals may be used instead of the more expensive purified substances. An analysis showing the percentage composition of the substance or at least a guarantee of the percentage of the pure substance contained should always be obtained when purchasing chemicals in large quantities.

THE SUPPLY OF WATER.

The principal ingredient of all spray fluids is water and it is very important to arrange for an efficient supply. Many spray fluids may be made on the garden from chemicals or stock solutions prepared or weighed out at the factory. It is often possible to obtain water at different places on the estate and so reduce heavy cost of transport. The extreme purity of the water supply is not a matter of very great moment. The main point is that sources from which water can be obtained should be distributed at frequent intervals throughout the garden. If water is muddy it can easily be strained through a cloth, if it be impure the strength of the solution may be modified accordingly.

When spraying was carried out on a small scale only, managers were contented with the old methods of carrying water in kerosine tins, buckets, barrels and the like. Some improvement in method is essential when spraying on a large scale is attempted. Planters with engineering training will probably experience little difficulty

° The number of bushes per acre for various distances of planting will be found in Appendices on pages 66 and 67.

in making arrangements which will reduce the labour required to a minimum. The following hints may be useful.

Pipe-lines.—Pipes constructed of bamboo with the diaphragms at their nodes removed, will often be found useful. In cases where it is intended to spray regularly it may be found advisable to put down a certain amount of permanent iron pipe-lines for the purpose.

Pumps.—Portable pumps of simple construction save much labour in cases where it is necessary to raise water from nullahs or wells. There are many suitable pumps on the market; where large quantities of water are being used it may be found expedient to employ a portable motor pumping outfit. Motor pumps, suitable for use on tea gardens, have been receiving the attention of engineering firms for some time and there are a number of outfits at reasonable prices which appear to be suited to the special conditions. Whenever possible, the carriage of water by hand in small vessels such as buckets should be avoided. It is very expensive and rarely necessary.

THE PREPARATION OF SPRAY FLUIDS.

Spray fluids must be accurately prepared if the greatest efficiency is to be obtained. A mistake in the preparation of a spray fluid may not only render the whole operation of spraying useless but may also be the cause of serious damage to the tea. The formulae of the various spray fluids which we have described are arrived at as the result of careful chemical investigation and they should be accurately adhered to. The preparation of a spray fluid is a delicate chemical manipulation and requires intelligent supervision.

Ready-made preparations.—There are a number of excellent preparations on the market, which merely require dilution with water to be ready for use and in cases where it is impossible to provide the supervision necessary for the successful preparation of spray fluids on the estate their use is recommended.

Weighing out chemicals.*—Weighing machines which are correct to a quarter of an ounce are necessary for the preparation of

* For tables showing a comparison of various weights and measures see Appendix p. 66.

spray fluid. They should be carefully looked after ; as they soon become inaccurate if they are carelessly handled. It must be remembered that many of the chemicals in common use in spraying attack metals, and it is unwise to place them on the unprotected metal pans. If this is done not only will the scale pans be damaged but the chemicals will be contaminated.

Receptacles.—The vessels in which the solutions are prepared should be numbered and their respective volumes determined. The correct amount of the dry chemicals for the preparation of the solution should be weighed out and enclosed in bags or packets each bearing clearly marked upon them, the number of the receptacle for which they are intended. To avoid spilling, the vessels in which the solutions are prepared should never be filled to the brim but only to a mark denoting a definite volume.

The manufacture of stock solutions.—When using chemicals which are not readily soluble or which for some reason or other are difficult to handle, it is advisable to prepare strong solutions for distribution instead of using the dry substances. When this is done instead of weighing out the correct quantity of the chemical for each receptacle each time spraying is done, a measured volume of the stock solution is used, which will contain the requisite weight of the dry chemical for each vessel. In the preparation of stock solutions it should be remembered that the maximum amount of a substance which will dissolve in a given quantity of liquid varies with the temperature. When a solution contains the maximum amount of the dissolved substance at any particular temperature it is said to be saturated. If the solution cools, the same amount cannot under ordinary circumstances remain in solution and a portion separates out usually in the form of crystals. Stock solutions therefore should not be made so strong that there is a possibility of this occurring.

Testing solutions.—The preparation of solutions is most important and unfortunately it is most difficult to supervise it properly. One way of testing the strength of solutions which have been made up according to a given formula is by evaporating a known quantity to dryness and weighing the residue. A more convenient

but not so accurate a method is by means of an instrument termed a *hydrometer*. This is merely a graduated float. It works on the principle that a floating body sinks until it has displaced a weight of liquid equal to its own weight. The weight of a constant volume of solution is increased by substances dissolved in it in proportion to the amount in solution. Hence a body placed in a 5% solution would not sink so much as it would in a 2% solution or in the plain solvent. A rise in temperature causes the expansion of the liquid so that its density decreases and the hydrometer sinks. Hydrometers may be obtained in glass or metal. There are various scales in common use, a set of hydrometers reading from 0° to 40° degrees Baumé for liquids heavier than water will be found suitable for garden use. In appendix 2 a table of comparison between specific gravity and degrees Baumé will be found. To find the percentage of a given substance in solution it is necessary to find the temperature of the solution and the number on the scale to which the hydrometer sinks. The percentage may then be obtained by reference to tables. Unfortunately tables are only available for a few of the chemical solutions used in spraying, and the tables available only give the percentages present at one temperature. It is, however, frequently possible to warm or cool the solution to be tested to the temperature given in the table. When altering the temperature in this way it is advisable to stir frequently in order to avoid incorrect thermometer readings.* But in most cases planters will only require to find out whether the solutions prepared are of the strength desired. The strength of the solution to be tested may be measured by a hydrometer of any scale against that of a solution known to have been correctly prepared. The standard sample may be kept in a bottle for use as occasion requires. In the case of very strong solutions it is advisable to dilute them with an equal volume of water before bottling. When the standard sample has been diluted it is of course necessary to proportionately dilute the sample to be tested. To avoid loss of water by evaporation thus causing the solution to be more concentrated than it should be, the bottles should be kept tightly corked. Needless to say it is unwise to store solutions which are likely to

* For a comparison of the readings of different thermometers see Appendix, page 70.

PLATE X.

alter in composition. In such cases fresh samples would require to be prepared whenever it is desired to carry out the tests. If the hydrometer sinks deeper in the solution under examination than it does in the test solution it shows that the solution is too weak. If it sinks less deeply the solution is too strong.

Storage vessels.—A few remarks are called for with regard to the vessels in which strong solutions are prepared and stored. Substances which may have no action on metals when they come into contact with them in the form of solutions of the concentration employed in spraying, may corrode them quickly when they are in the form of the more concentrated standard solutions. Careful precaution must be taken to avoid prolonged contact between the machines and the spray fluids in the latter case. Barrels and tubs of hard wood are very useful for most solutions, because they are hardly acted upon at all, chemically, by most of the fluids used for spraying.

Paint for protecting iron or concrete tanks from the action of spray chemicals.—Iron or concrete tanks may be used for spray fluids if the surface, which come into contact with the chemicals, be properly protected by a coat of paint which is unacted upon by the chemicals composing the spray fluid. It is very important that paint used for this purpose should be applied properly. Otherwise it will peal off and both the solution and the tanks will be damaged. There are many preparations on the market for this purpose, a number of which are said to be unaffected by high temperatures. This is a desirable feature as it is sometimes necessary to boil solutions.

Heating solutions.—Some spray fluids, such as lime-sulphur, require boiling and it may be expedient to hasten the solution of some other chemicals by heat. Heating by steam is generally much more convenient than by fires placed underneath the receptacles. When the heating is done by a jet of steam passing directly through the liquid allowance should be made for the amount of water which will condense from the steam jet. The chemicals should therefore be dissolved in less than the right amount of water, the solution being made up to the required strength subsequently.

CHARGING MACHINES.

Care must be taken to avoid loss of time and material in the operation of filling spraying machines. In most cases special accessories to facilitate charging are supplied with the machines.

Funnels.—Whenever it is necessary to ladle fluids into the container of the machines, the use of a broad mouthed funnel constructed of suitable material saves the spilling of a great deal of solution and expedites the operation very considerably.

Strainers.—When strainers are not provided with the machine they should be fitted into the funnels. All spray fluids which may contain solid matter, such as grit, etc., should be strained, otherwise clogging of the nozzles and smaller pipes of the machine may take place. Strainers of brass wire gauze may be easily made and fitted inside the funnels, so that both straining and filling may be done at one operation.

Pumps.—In the case of sprayers of the battery type the straining and filling operations are done by a pump. The use of a simple pump, constructed of brass or other suitable metal, would facilitate the charging of other varieties of machine. Two or three strokes of a pump with a fairly large cylinder would fill a sprayer of average size.

THE APPLICATION OF THE SPRAY FLUIDS.

The aim in spraying should be to cover the foliage of the plants with an unbroken film of spray fluid of such thickness as will adhere properly. This state is reached when the liquid commences to drip from the sprayed shoots. The fact that liquid is dripping off shows that no more will stick on and further application would be wasteful. All parts of the bush should be sprayed evenly. To facilitate the even distribution of the fluid it is advisable to spray upwards from below at first so that the under-surfaces of the leaves and twigs are covered with spray fluid and any drippings from them fall down on to the upper surfaces of foliage lying below them. The bush should then be sprayed from above. If the bush be sprayed only from above the under sides of the leaves frequently remain untreated although the upper surfaces may be drenched.

SUPERVISION.

The following hints may aid planters in controlling the work of spraying :

Testing solutions.—The preparation of solution is most important and unfortunately it is difficult to supervise it properly. Methods of testing solutions have been mentioned in connection with the preparation of spray fluids, p. 61, and it is unnecessary to repeat them here.

Examination of the work of the operators is fairly simple. The under-surfaces of the leaves in the centre of the bush should receive special attention. If they are found to have been effectively sprayed on both sides it is fairly certain that the spraying has been done carefully.

Inspection of spraying machines.—The spraying machines themselves should be inspected at frequent intervals. The condition of the washers and rubber tubes should be specially noted. The former should be frequently replaced. If the machines are not looked after carefully they will certainly get out of order and cause loss of time. It is a good plan to number the machines and allot them for the whole spraying operation, each operator being held responsible for the machine allotted to him.

Waste of solution by spilling should be avoided. Most managers call the attention of coolies to any leaf dropped about at leaf weighing. There is no more reason for the waste of solution than there is for the waste of tea leaf. Although the loss may not be very serious in itself attention to such small details tends towards general efficiency in carrying out spraying operations.

If the arrangements for the water and chemical supply and the distribution of the fluid have been well thought out, special supervision will not be necessary as any dislocation, such as excess supply at one place or lack of material at another, in the garden, will be at once apparent.

APPENDIX 1.

Useful data.

Weight.

English.	Indian.	Metric.
Ton.	28 maunds.	101·6048 kilogram.
Cwt.	1 maund 16 seers.	50·802 ,,
Lb.	8 chittacks or ½ seer.	453·593 grams.
Oz.	½ chittack.	28·349 ,,

Indian.	English.	Metric.
Maund.	80 lbs. or ·71 cwt.	36·287 kilogram.
Seer.	2 ,,	987·186 grams.
Chittack.	2 oz.	56·699 ,,
Tolah.	0·4 ,,	11·339 ,,

Metric.	English.	Indian.
Kilogram.	2·205 lbs.	1·1025 seers or 1 Govt. seer.
Gramme.	·0022051 lb.	·0011025 seer.

The weight of 1 rupee = 1 tolah.
80 rupees = 1 seer.

Area.

Indian.

A nul = 12 feet or 4 yards.
Square nuls in 1 acre = 302·5.

Plants per Acre.

Square or Rectangular Planting.

—	3 feet 0 inches.	4 feet 0 inches.	5 feet 0 inches.	6 feet 0 inches.
3 feet 0 inches.	4,840	.....	.....	.....
4 ,, 0 ,,	3,630	2,722	.....	.....
5 ,, 0 ,,	2,904	2,178	1,742	.....
6 ,, 0 ,,	2,420	1,815	1,452	1,210

4 feet 6 inches square planting = 2,150 plants per acre.

Plants per acre.

Triangular or Rhombic Planting.

Distance between Plant.	Plants per acre.	Distance between Plants.	Plants per acre.
4 feet 0 inches ...	3,143	5 feet 6 inches ...	1,662
4 „ 6 „ ...	2,483	6 „ 6 „ ...	1,397
5 „ 0 „ ...	2,011	.....	.....

Volume.

1 Gallon	= ·16	cubic feet	or 277·274	cubic inches	= 4543·458	cubic cent.
1 Quart	= ·04	„	or 69·318	„	= 1135·864	„
1 Pint	= ·02	„	or 34·66	„	= 567·932	„
1 Oz.	= ·001	„	or 1·733	„	= 28·3966	„
1 Litre	= ·035317	„	or 61·02705	„	= 1000·	„
1 C. Cm.	= ·000035	„	or ·06103	„		

Water.

1 Gallon	= ·16	cubic feet	= 10	lbs.
1 Cubic foot	= 6·2355	gallons	= 62·35	„
1 Fluid oz.	= 1·733	cubic inches	= 1 oz. avoir.	= 437·5 grains.

APPENDIX 2.

Table showing comparison of degrees of Baumé by hydrometer with specific gravity.

For liquids lighter than water.

Degrees of Baumé.	Specific gravity.	Degrees of Baumé.	Specific gravity.
0	...	36	0·848
1	...	37	0·843
2	...	38	0·838
3	...	39	0·833
4	...	40	0·829
5	...	41	0·824
6	...	42	0·819
7	..	43	0·815
8	...	44	0·810
9	...	45	0·806
10	1·000	46	0·801
11	0·993	47	0·797
12	0·986	48	0·792
13	0·979	49	0·788
14	0·973	50	0·784
15	0·967	51	0·781
16	0·960	52	0·776
17	0·954	53	0·771
18	0 948	54	0·769
19	0·942	55	0·763
20	0·935	56	0·759
21	0·929	57	0·755
22	0·924	58	0·751
23	0·918	59	0·748
24	0·912	60	0·744
25	0·906	61	0·740
26	0·901	62	0·736
27	0·895	63	...
28	0·889	64	...
29	0·884	65	...
30	0·879	66	...
31	0·873	67	...
32	0·868	68	...
33	0·863	69	...
34	0·858	70	...
35	0·853		

APPENDIX 2—*concluded.*

Table showing comparison of degrees of Baumé by hydrometer with specific gravity.

For liquids heavier than water.

Degrees of Baumé.	Specific gravity.	Degrees of Baumé.	Specific gravity.
0	1·000	37	1·337
1	1·007	38	1·349
2	1·014	39	1·361
3	1·020	40	1·375
4	1·028	41	1·388
5	1·034	42	1·401
6	1·041	43	1·414
7	1·049	44	1·428
8	1·057	45	1·442
9	1·064	46	1·456
10	1·072	47	1·470
11	1·080	48	1·485
12	1·088	49	1·500
13	1·096	50	1·515
14	1·104	51	1·531
15	1·113	52	1·546
16	1·121	53	1·562
17	1·130	54	1·578
18	1·138	55	1·596
19	1·147	56	1·615
20	1·157	57	1·634
21	1·166	58	1·653
22	1·176	59	1·671
23	1·185	60	1·690
24	1·195	61	1·709
25	1·205	62	1·729
26	1·215	63	1·750
27	1·225	64	1·771
28	1·235	65	1·793
29	1·245	66	1·815
30	1·256	67	1·839
31	1·267	68	1·864
32	1·278	69	1·885
33	1·289	70	1·909
34	1·300	71	1·935
35	1·312	72	1·960
36	1·324		

APPENDIX 3.

Comparison of different thermomete

Centigrade or Celsius.	Fahrenheit.	Centigrade or Celsius.	Fahrenheit.
100	212	60	140
99	210·2	59	138·2
98	208·4	58	136·4
97	206·6	57	134·6
96	204·8	56	132·8
95	203	55	131
94	201·2	54	129·2
93	199·4	53	127·4
92	197·6	52	125·6
91	195·8	51	123·8
90	194	50	122
89	192·2	49	120·2
88	190·4	48	118·4
87	188·6	47	116·6
86	186·8	46	114·8
85	185	45	113
84	183·2	44	111·2
83	181·4	43	109·4
82	179·6	42	107·6
81	177·8	41	105·8
80	176	40	104
79	174·2	39	102·2
78	172·4	38	100·4
77	170·6	37	98·6
76	168·8	36	96·8
75	167	35	95
74	165·2	34	93·2
73	163·4	33	91·4
72	161·6	32	89·6
71	159·8	31	87·8
70	158	30	86
69	156·2	29	84·2
68	154·4	28	82·4
67	152·6	27	80·6
66	150·8	26	78·8
65	149	25	77
64	147·2	24	75·2
63	145·4	23	73·4
62	143·6	22	71·6
61	141·8	21	69·8

APPENDIX 3.—*concluded.*

Comparison of different thermometers.

Centigrade or Celsius.	Fahrenheit.	Centigrade or Celsius.	Fahrenheit.
20	68	9	48·2
19	66·2	8	46·4
18	64·4	7	44·6
17	62·6	6	42·8
16	60·8	5	41
15	59	4	39·2
14	57·2	3	37·4
13	55·4	2	35·6
12	53·6	1	33·8
11	51·8	0	32
10	50		

APPENDIX 4.

Table showing the strength of solutions of sodium carbonate by specific gravity at 23°C.

Specific gravity.	Per cent of Na_2CO_3 +10 Aq. (crystals.)*	Per cent of Na_2CO_3 (ash.)†	Specific gravity.	Per cent of Na_2CO_3 +10 Aq. (crystals.)*	Per cent. of Na_2CO_3 (ash.)†
1·0038	1	·370	1·1035	26	9·635
1·0076	2	·741	1·1046	27	10·005
1·0114	3	1·112	1·1117	28	10·376
1·0153	4	1·482	1·1158	29	10·746
1·0192	5	1·853	1·1200	30	11·118
1·0231	6	2·223	1·1242	31	11·488
1·0270	7	2·594	1·1284	32	11·859
1·0309	8	2·965	1·1326	33	12·230
1·0348	9	3·335	1·1368	34	12·600
1·0388	10	3·706	1·1410	35	12·971
1·0428	11	4·076	1·1452	36	13·341
1·0468	12	4·447	1·1494	37	13·712
1·0508	13	4·817	1·1536	38	14·082
1·0548	14	5·188	1·1578	39	14·453
1·0588	15	5·558	1·1620	40	14·824
1·0628	16	5·929	1·1662	41	15·195
1·0668	17	6·299	1·1704	42	15·566
1·0708	18	6·670	1·1746	43	15·936
1·0748	19	7·041	1·1788	44	16·307
1·0789	20	7·412	1·1830	45	16·677
1·0830	21	7·782	1·1873	46	17·048
1·0871	22	8·153	1·1916	47	17·418
1·0919	23	8·523	1·1959	48	17·789
1·0953	24	8·894	1·2002	49	18·153
1·0994	25	9·624	1·2045	50	18·530

Table showing the strength of solution of Potassium Hydrate (Caustic potash) and Sodium Hydrate (Caustic soda) by specific gravity at 15°C. = 59°F.

Per cent.	Specific gravity, Potassium-Hydrate.	Specific gravity, Sodium-Hydrate.	Per cent.	Specific gravity, Potassium-Hydrate.	Specific gravity, Sodium-Hydrate.
5	1·036	1·059	40	1·411	1·437
10	1·077	1·115	45	1·475	1·488
15	1·124	1·170	50	1·539	1·540
20	1·175	1·225	55	1·604	1·591
25	1·230	1·279	60	1·667	1·643
30	1·288	1·332	65	1·729	1·695
35	1·349	1·384	70	1·790	1·748

Table showing the strength of solutions of Copper sulphate by specific gravity at 18° C. = 64·4° F.

Specific gravity.	Per cent of $CuSO_4 + 5H_2O$. (crystals.)*	Per cent of $CuSO_4$. (dry powder.)†	Specific gravity.	Per cent of $CuSO_4 + 5H_2O$. (crystals.)*	Per cent of $CuSO_4$ (dry powder.)†
1·0063	1	·637	1·1063	16	10·200
1·0126	2	1·275	1·1135	17	10·837
1·0190	3	1·912	1·1208	18	11·474
1·0254	4	2·550	1·1281	19	12·111
1·0319	5	3·187	1·1354	20	12·750
1·0384	6	3·825	1·1427	21	13·387
1·0450	7	4·462	1·1501	22	14·025
1·0516	8	5·100	1·1585	23	14·662
1·0582	9	5·737	1·1659	24	15·300
1·0649	10	6·375	1·1738	25	15·938
1·0716	11	7·012	1·1817	26	16·674
1·0785	12	7·650	1·1898	27	17·211
1·0854	13	8·287	1·1980	28	17·848
1·0923	14	8·925	1·2063	29	18·486
1·0993	15	9·562	1·2146	30	19·125

* Chemical formula for crystalline copper sulphate.

† Chemical formula for copper sulphate dry powder.

APPENDIX 5.

Lime-Sulphur Solution.

Commercial concentrated solutions of Lime-sulphur vary in strength and tables are given here which will guide planters who use the commercial solutions in preparing mixtures of a suitable strength for use. A Hydrometer graduated in degrees Baumé may be procured. This, when floated in a vessel containing some of the commercial solution, will sink to a depth depending on the density of that solution, and this is read off on a scale fixed to the instrument. Opposite the corresponding number in the first column of this table will be found the number of gallons of water to be added to one gallon of the commercial solution when preparing the spray solution.

Reading of Hydrometer in Degrees Baumé.	Number of gallons of water to 1 gallon of commercial solution.	
	For spraying bushes in leaf.	For spraying bushes after pruning.
35	45	9
34	43½	8¾
33	41¼	8¼
32	40	8
31	37½	7½
30	36¼	7¼
29	34¼	6¾
28	32¾	6½
27	31	6
26	29½	5¾
25	27¾	5¼
24	26	5
23	24¼	4½
22	22¾	4¼
21	21¼	3¾
20	19¾	3½
19	18¼	3¼
18	17	3
17	16	2¾
16	15	2½
15	14	2¼
14	12¾	2

APPENDIX 6.

The proportions of Copper sulphate crystals which may be dissolved in water at different temperatures.

At temperature.	100 parts of water dissolve.
10°C.	36·9
20°C.	42·3
40°C.	56·9
80°C.	118·0
100°C.	203·3

C. O. P.—1000—24-3-25.